JAN. 1919
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ELECTRICAL EXPERIMENTER

SCIENCE AND INVENTION

OVER 175 ILLUST.

SMOKE BARRAGE SAVES ESCAPING PLANE

SEE PAGE 612

Electrical Experimenter

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EDITORIAL

Electric Music

THERE are many different ways of producing music, and as our culture advances the desire for better and still better music becomes a craving of civilization. From the ancient tom-tom to a Stradivarius violin is a long cry, and the chances are that as our musical tastes become more refined, still better instruments will become necessary and highly desirable.

There are few instruments giving a more mellow and a more "human" sound and quality of tone than a fine violin, but we have no hesitancy in saying that it should be possible to obtain still better results by electrical means. The field of purely electrical music has hardly been touched. Some years ago an American inventor produced the Telharmonium. This was one of the earliest and best attempts at pure electrical music. The Telharmonium was invented by Dr. Thaddeus Cahill and he used alternating current generators, each of a certain frequency; if a telephone receiver were connected in the circuit, the latter would give forth a certain very pure note. By using a switchboard arranged in the form of an organ keyboard, wonderful musical effects were produced.

Another more recent attempt was the pure electrical music discovered thru researches of Dr. Lee de Forest. He used his audion bulbs in connection with a telephone receiver, and obtained beautiful flute-like tones of the greatest purity. The two devices just described necessitated the use of a telephone receiver to translate the electrical impulses into sonorous vibrations, and this is a great disadvantage, for it ties us to a thin diafram, which in itself cannot produce the very purest tones obtainable. As one can readily understand, the limitations of a diafram are very great and while it is possible to obtain a single pure note, it is a different matter where several pure notes in different octaves are to be reproduced simultaneously.

A way out is suggested by the writer by pressing into service the thermo-telephone which employs no diafram at all, but uses a very fine platinum wire of microscopic cross-section. This platinum wire, heating and cooling in unison with the electrical vibrations, imprest upon it imparts these impulses to the surrounding air. With this device very pure electrical music can be obtained.

There should be of course many other ways to actually produce pure electrical music, and here is a wonderful opportunity for experimenters and inventors. To the writer's mind, it seems not at all impossible that we should take a metallic wire stretched taut and by impressing an electric current upon it, vary its heating and cooling effects so as to produce pure sounds in a suitable receiver such as a thermo-telephone.

Dr. de Forest has shown us that beautiful music can be produced in a vacuum tube. Paradoxical as it seems, this nevertheless is a fact. There must be many other ways of producing vibrations in a vacuum tube which can be translated into an electrical current, thus producing music.

There are also certain ways of making electromagnets produce music—this without the adjunct of telephone receivers,—by vibrating their entire structure. Many other means will undoubtedly suggest themselves to our students and scientists.

H. GERNSBACK.

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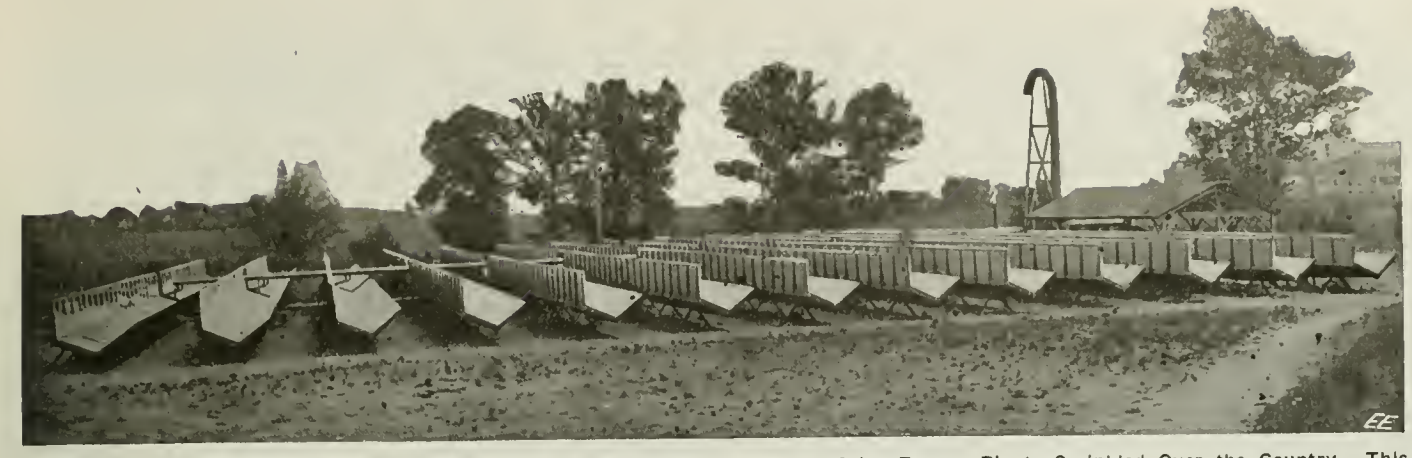


Some Day In the Near Future We Shall Undoubtedly See Hundreds of These Solar Energy Plants Sprinkled Over the Country. This Large Plant is In Texas. The Mirrors Reflect the Sun's Rays Onto Special Boilers, the Steam Produced Running a Steam Engine, Connected to a Dynamo. Current From the Dynamo Runs a Motor Pump Which Lifts Water to a Height of Sixty Feet.

Solar Engine Uses Sun's Energy

SIX thousand degrees Centigrade is the computed temperature of the sun. Its light giving power is equal to 27,000,000,000 candlepower, a quarter of a mile away. Scientists tell us that only the 2,735-millionth part of the total energy radiated from the sun reaches our earth, but if this were ever caused to stop for any reason our planet would turn into a dead, frigid ball of rock; the present average annual temperature of 13° C., would change, without the heat of the sun, to 73° C., of frost, it is calculated.

Experiments show that the power of the atmosphere to trap heat is largely due to the *water vapor* that it contains. It is also due to some extent, to the *carbon dioxid gas* that is one of its minor constituents, points out Prof. Garrett P. Serviss. Carbon dioxid is a remarkable heat retainer, but there is only a very small quantity of it in the air compared with the vast bulk of the atmosphere. It only amounts to about 3/100 of 1 per cent. But there is this significant fact about it, viz., that its amount is variable, to a slight degree at the present time, while there is evidence from past geological history that once it was vastly more abundant than it is now.

Now, how much carbon dioxid must the air gain in order that a perceptible effect on the temperature may be produced? Arrhenius answers this question for us. He says that if all the carbon dioxid now in the air were removed, the average temperature would fall nearly 38 degrees Fahrenheit. On the other hand, if the present amount were doubled the temperature would rise more than 7 degrees, and if it were quadrupled the rise would amount to nearly 14½ degrees which would be far more than enough to banish all the glacial suffering that we had to endure last winter. Even the smaller amount of increase (7 degrees) would probably suffice for that.

These facts are very interesting from a technical point of view, indeed. The practical aspect of solar energy lies at present in the hands of those who are endeavoring to perfect a solar motor—i.e., an engine or electric generating device which, when the sun's rays strike it, will develop steam to operate a steam engine, or electricity to charge electric accumulators or storage batteries. Those interested in this branch of science will find of great interest several articles which have appeared in back numbers of this journal.*

Considering later developments of a practical nature in the line of solar engines and boilers, we may take up the work of Mr. Shuman, of Philadelphia, Pa., who later collaborated with a Mr. Boys, of England. They were able in their final developments to operate a 100 horsepower engine by means of solar energy. This plant was built at Meadi on the Nile, Egypt. Prior to this excellent work, however, we may consider briefly the early solar engines developed and tried out at Philadelphia, Pa., by Frank Shuman, upon which work he started in 1906. One of these solar engine plants installed in Texas being illustrated herewith. The heat of the sun's rays strikes a large number of mirrors, which reflect the heat to special boilers. These produce steam to run an engine, the latter operating an electric dynamo. The current thus produced was capable of operating an electric motor pump which pumped water to a height of 60 feet above the ground.

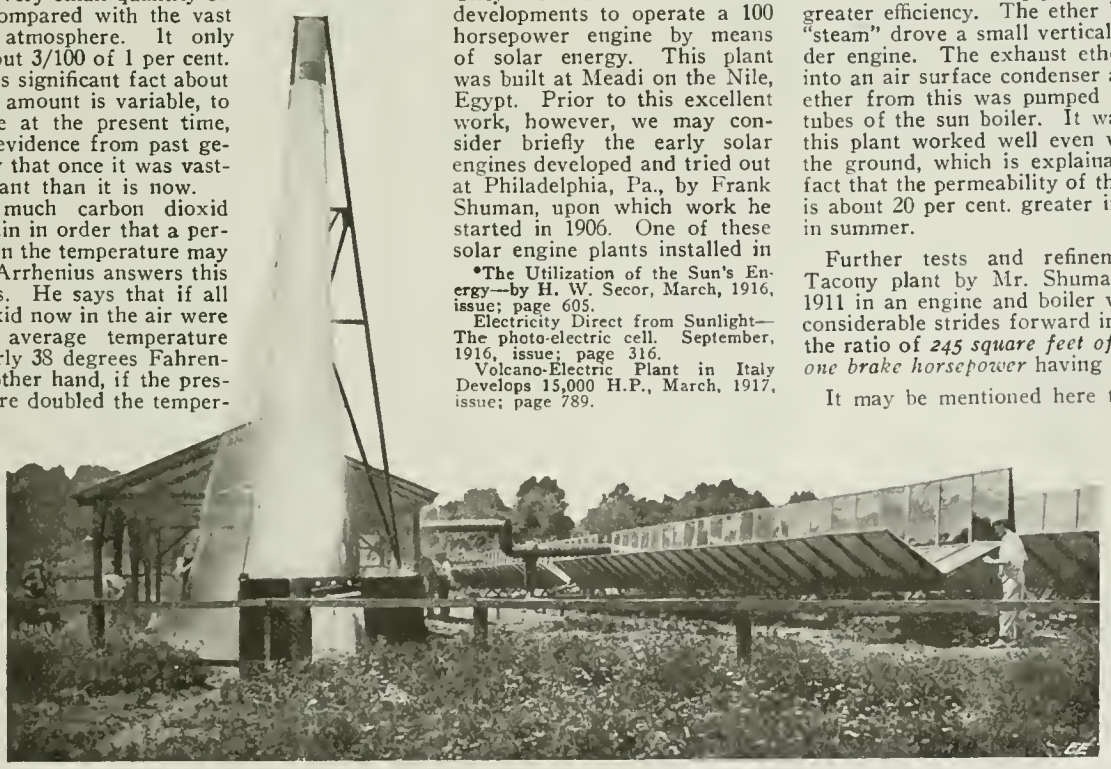
Mr. Shuman had running at Tacony, Pa., a practical plant of this type, which developed about 3½ horsepower by using 1,200 square feet of sunshine that was allowed to fall on a fixt horizontal water box. This box was fitted with a glass top and a series of parallel horizontal black pipes were immersed in the water. These pipes, containing *ether*, exposed 900 square feet of surface to the solar radiation. The water also became heated and carried the heat to the underside of the pipes, thus realizing a greater efficiency. The ether boiled and its "steam" drove a small vertical, single cylinder engine. The exhaust ether vapor past into an air surface condenser and the liquid ether from this was pumped back into the tubes of the sun boiler. It was found that this plant worked well even with snow on the ground, which is explainable from the fact that the permeability of the atmosphere is about 20 per cent. greater in winter than in summer.

Further tests and refinements to the Tacony plant by Mr. Shuman resulted in 1911 in an engine and boiler which showed considerable strides forward in their design, the ratio of *245 square feet of sunshine per one brake horsepower* having been attained.

It may be mentioned here that the pipes constituting the sun boilers have invariably been *blackened*. For low temperatures lampblack has been used as the absorber, but where high temperatures were required platinum black was used.

(*Continued on page 672*)

*The Utilization of the Sun's Energy—by H. W. Secor, March, 1916, issue; page 605.
Electricity Direct from Sunlight—The photo-electric cell. September, 1916, issue; page 316.
Volcano-Electric Plant in Italy Develops 15,000 H.P., March, 1917, issue; page 789.



Photos © by International Feature Service.

Here We See the Sixty Foot Stream of Water, Discharging. The Electric Power to Pump This Stream of Water is All Furnished By the Mirrors Which Gather and Reflect the Sun's Rays Onto Special Boilers.

Nikola Tesla and His Inventions

By H. Gernsback

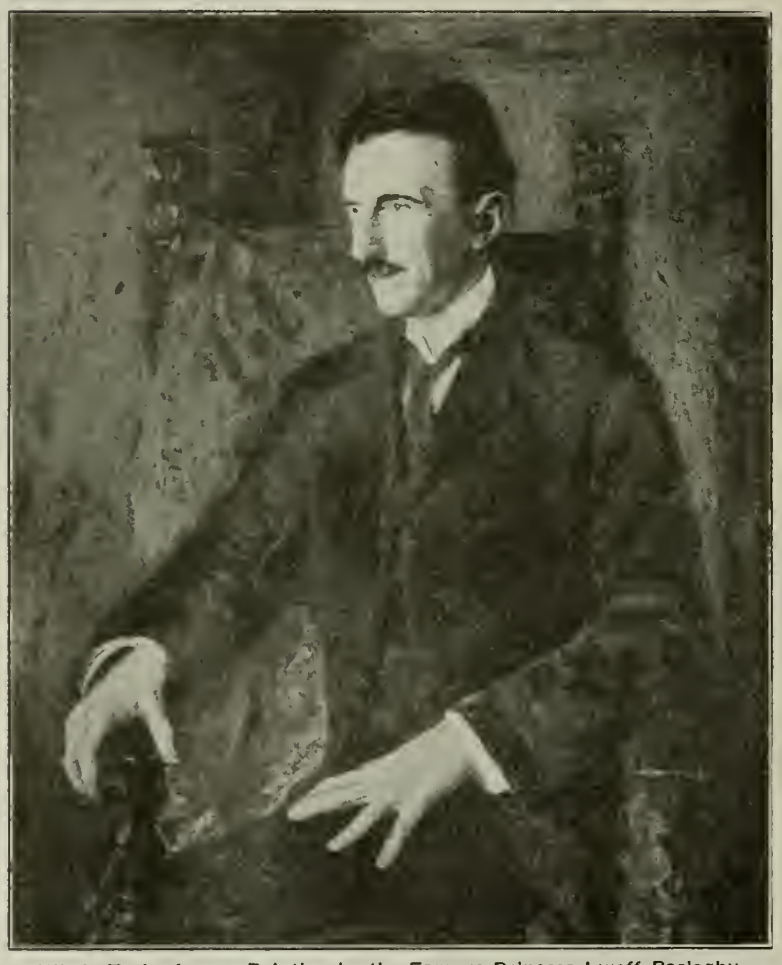
AN ANNOUNCEMENT

SEVERAL years ago, in the course of a discussion, a well-known journalist asked me whom I considered at present the world's greatest inventor. I said: "If you mean the man who really *invented*, in other words, *originated* and *discovered* — not merely *improved* what had already been invented by others, then without a shade of doubt, Nikola Tesla is the world's greatest inventor, not only at present, but in all history."

My friend was much surprised and voiced his astonishment. "Surely," said he, "you do not mean to place Tesla ahead of such great men as Archimedes, Faraday or Edison?"

"That is exactly what I mean," I replied, "and before twenty-five years have elapsed the world at large will echo my opinion."

"But listen," persisted my friend, "who on earth is this man Tesla anyway? What are his wonderful inventions, what great thing has he ever done? How is it that the world at large does not know him?"



Nikola Tesla, from a Painting by the Famous Princess Lwoff-Parlaghy. This Picture Has Never Been Published Before.

"To begin with, and the better to impress you," I replied, "Tesla has secured more than one hundred patents on inventions, many of which have proved revolutionary. Science accords to him over 75 original *discoveries*, not mere mechanical improvements. Tesla is an originator in the sense that Faraday was an originator. Like the latter he is a pioneer blazing the trail; aside from this he is a discoverer of the very highest order."

"Ninety percent of the entire electrical industry pays tribute to his genius. All electrical machinery using or generating alternating current is due to Tesla. High tension current transmission without which our long distance trolley cars, our electrified lines, our subways would be impossible, are due to the genius of Tesla. The Tesla Induction Motor, the Tesla Rotary Converter, the Tesla Phase System of Power Transmission, the Tesla Steam and Gas Turbine and the Tesla Coil and Oscillation Transformer are perhaps his better known inventions.

"As to your last question, namely, why the world at large does not know Tesla, it is answered best by stating that he has committed the unpardonable crime of not having a permanent press agent to shout his greatness from the housetops. Then, too, most of Tesla's inventions, at least to the public mind, are more or less intangible on account of the fact that they are very technical and, therefore, do not catch the popular imagination, as, for instance, wireless, the X-ray, the airplane, or the telephone."

The trouble with Nikola Tesla is that he lives a century ahead of his time. He has often been denounced as a dreamer even by well informed men. He has been called crazy by others who ought to know better. For Tesla talks in a language that most of us do not as yet understand. But as the years roll on Science more and more appreciates his greatness, and begins to pay him tribute more and more.

In 1893, three years prior to the earliest attempts in Hertz wave telegraphy, Tesla first described his wireless system and took out patents on a number of novel devices which were then but imperfectly understood. Even the electrical world at large laughed at these patents. But large wireless interests had to pay him tribute in the form of real money, because his "fool" patents were recognized to be fundamental. He actually antedated every important wireless invention.

A few weeks ago the world read thru news dispatches of a great wireless discovery—the static eliminator. But Tesla had not only patented systems overcoming this and other forms of interference but had actually constructed and successfully operated devices years ago in Colorado, under conditions where static interference was troublesome to an extraordinary degree. A photograph of one form of his apparatus is published with a note from him for the first time elsewhere in this issue of the ELECTRICAL EXPERIMENTER And so it goes. The world smiles an unbelieving smile, but Tesla's master mind invariably sets the world aright.

I first read about Tesla in a well-known German weekly publication when I was less than 15 years old. The Editor of that publication reproduced his picture on a full page and paid high tribute to Tesla, hailing him as the world's coming greatest electrician.

H. W. Buck, Chief Engineer, President of the American Institute of Electrical Engineers, among others, said: "The work of Nikola Tesla in his great conception of his rotary field seems to me one of the greatest feats of imagination which has ever been attained by human mind."

Lord Kelvin, before the British Association, commenting upon the Tesla Transformer exhibited, said: "This is a wonderful development of the induction coil destined to be of great importance."

Electrical Review, commenting upon the wireless: "Mr. Tesla's

researches in this field have attracted world-wide attention, and his is undoubtedly the master mind."

Der Electro-Technische Anzeiger, Berlin, and *Elektrizität,* Leipzig, Germany, (commenting upon Tesla's work): "It is a combination of the grandest power of technical performance with the most vivid imagination, such as has never before manifested itself in the human mind."

Brigadier Allen, of the United States War Department (commenting upon Tesla's Turbine): "Something new in the world. Officers are greatly impressed with it."

While studying abroad I read every scrap of his work I could lay my hands on. I performed most of his high frequency experiments, and the more I saw of his work the more imprest I became. Some years ago as Editor of *Modern Electrics,* I met him in a New York shop where his famous turbine models were first built. I was fascinated with the tall, gaunt man, then about 50 years old, but looking less than 30. His extraordinary face, with his deep set blue eyes, proclaimed the intense thinker—the philosopher. A few minutes' chat with him left me more than ever convinced of his greatness.

Further contacts during the past few years still enhanced my opinion of him. Tesla is a man of extraordinary knowledge. He is remarkably well read and has a photographic memory whereby it is possible for him to recite page after page of nearly every classical work, be it Goethe, Voltaire or Shakespeare. He speaks and writes twelve languages. He is an accomplished calculator, who has little use for tables and text-books and holds the sliding rule in contempt. Tesla has received numerous honors and distinctions of all kinds. He is a knight of several orders, holder of many titles and diplomas. Some time ago he was awarded the Elliott Cresson gold medal by the Franklin Institute and last year the Edison medal by the American Institute of Electrical Engineers. Many extraordinary distinctions have been offered to him which he has declined. As of timely interest one instance may be mentioned. At the announcement of Tesla's high frequency discoveries, while the former Emperor of Germany was all-powerful and great men were eager for his favors, Tesla received an invitation from him and the Empress to repeat his celebrated experiments at the Royal Palace in Berlin. He forgot all about it and did not answer for one year, when he politely apologized for his inability to avail himself of the honor. Later the invitation was renewed and nearly two years past before Tesla answered to the same effect. After a lapse of time, however, upon the announcement of another important invention, he received the invitation for the third time, with the assurance that an altogether unusual honor was reserved for him. "Well, boys," said Tesla to his assistants after he laid the invitation which he never answered aside, "the Emperor must be a great man. I do not think that I would be capable of acting in this way if I were in his place." Perhaps the most remarkable tribute was paid to him when he made his famous experiments in Colorado in 1899. It was by J. Pierpont Morgan, the elder, who donated $150,000, which enabled Tesla to produce artificial lightning and incidentally to electrify the entire earth.

Some of Tesla's inventions have been of far-reaching importance in the War. The resources and productive powers of the country have been greatly increased thru extended use of his system of alternating current transmission and transformation of energy. Nearly ten million horsepower of water falls have been harnest by this means, thus saving forty percent of the entire coal output of the United States. The railroads have been electrified and his induction motor has revolutionized the steel industry and operation of factories. His electric drive has been adopted on the largest cruisers and battleships as the most perfect means of propulsion. His wireless inventions have proved indispensable and his oscillatory apparatus has been of inestimable service in chirurgical and therapeutic treatment in the field.

The technical prints abound with his work, his inventions, his discoveries. The following is only a partial list of terms now adopted and published in text books and technical works:

Tesla two-phase, three-phase, multi-phase, poly-phase system of power transmission
Tesla principle
Tesla rotating magnetic field
Tesla rotating magnetic field transformer
Tesla induction motor
Tesla split-phase motor
Tesla system of distribution
Tesla rotary transformer
Tesla system of transformation by condenser discharges
Tesla coil
Tesla oscillation transformer
Tesla electrical oscillator
Tesla mechanical oscillator
Tesla high frequency machines
Tesla dynamo-electric oscillator
Tesla tube
Tesla lamp
Tesla high-potential methods
Tesla inductor
Tesla marvels
Tesla impedence phenomena
Tesla electro-therapy
Tesla electrical massage
Tesla currents
Tesla transmission
Teslaic experiments
Tesla capacity
Tesla arclight system
Tesla third brush regulation
Tesla devices
Tesla sparks
Tesla arrangements
Tesla theory
Tesla point
Tesla Steam Turbine
Tesla Gas Turbine
Tesla Water Turbine
Tesla Pump
Tesla Compressor
Tesla Igniter
Tesla condensers
Tesla electro-static field
Tesla effects
Tesla wireless system
Tesla methods of wireless transmission
Tesla magnifying transmitter
Tesla telautomata
Tesla insulation
Tesla underground transmission, etc.

The other night the Editors of the "Experimenter had the opportunity of passing an evening with Tesla. We talked about many things, so interesting, that I will reserve them for another article—but mostly, of course, the conversation centered about Tesla himself.

"Dr. Tesla," I said to him, "you are aware of our great admiration for you, which may or may not be important. But the great public knows little of your mark. Even many of those technically educated—excuse the frankness—think that you are

(*Continued on page* 657)

BY *special arrangement the ELECTRICAL EXPERIMENTER will, beginning with the next issue, publish a series of articles entitled "My Inventions", by Nikola Tesla. The great inventor will contribute a signed article monthly, which articles will run for several years. Most of this material has never appeared in print before. The articles will be publisht in book form later. We consider this announcement the most important we ever made.* THE PUBLISHERS.

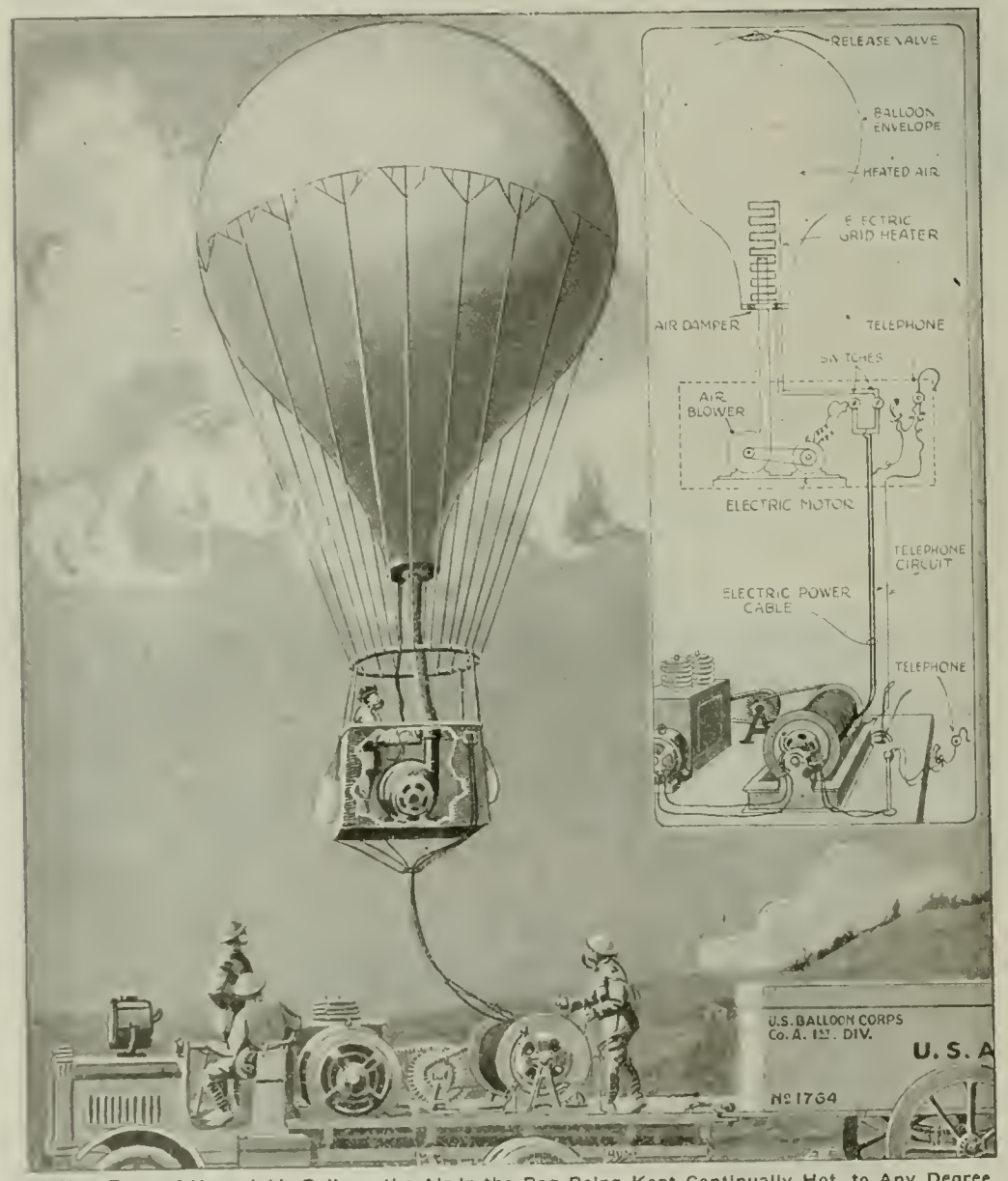
NIKOLA TESLA, *in the opinion of authorities, today is conceded to be the greatest inventor of all times. Tesla has more original inventions to his credit than any other man in history. He is considered greater than Archimedes, Faraday, or Edison. His basic, as well as revolutionary, discoveries for sheer audacity have no equal in the annals of the world. His master mind is easily one of the seven wonders of the intellectual world.*

H. GERNSBACK.

An All-Electric Hot Air Balloon

THE captive balloon as used by the Allied armies at the present time is invariably filled with hydrogen or other gas supplied from steel bottles containing this gas stored at a high pressure, or else it is obtained from manufacturing supply stations on the field. The first balloons ever used—the old "Montgolfières" of 1783—were made to rise by means of hot air, for, as we all know, heated air is lighter than cold air, and will always rise. If the heated air is of sufficient volume, it will also carry a body up with it, such as a balloon envelope for example. All of us have seen the simple balloons which patriotic Americans are wont to liberate on the Fourth-of-July, and which are composed of nothing more than a balloon-shaped paper bag at the bottom opening of which there is secured either an absorbent wick containing gasoline, or a small alcohol lamp. We simply light the lamp, and after a short time the heated air rushing up into the balloon causes the envelope to become very light and it rises in the air. Some of these balloons will travel for miles, and years ago it was not an uncommon sight in Europe to see hot-air balloons ascend with several men.

There has always been, however, a serious objection to a hot-air balloon where the heater was of the flame or similar type, for there was always in this case the constant danger of the balloon becoming ignited, with disastrous results. It has remained for Mr. James N. Lewis of Detroit, Michigan, to invent and patent an all-electric hot-air balloon, which is illustrated in detail in the accompanying illustration. Mr. Lewis makes use of an automobile winch to haul in the balloon, and to act as a mobile station, a trailer being hooked behind the winch, in which to carry the balloon bag and basket while being transported from one point to another. Either the automobile engine or a separate gasoline engine mounted on the truck drives a dynamo, which supplies current for an electric heater in the balloon. By means of suitable clutches, the engine may be caused to drive the dynamo, or else thru a chain drive, it may be connected up to rotate the cable winch drum. The dynamo makes connection to a duplex power cable reeled around the drum, and this leads up to the balloon basket. Also the telephone circuit is carried up to the balloon thru the drum or otherwise, so that those on the ground are in telephonic connection at all times with the observer in the balloon basket, and under battle conditions he would also be in telephonic communication at all times with "field headquarters," so as to report the position of enemy guns, troops, etc.



A New Form of Heated Air Balloon, the Air In the Bag Being Kept Continually Hot, to Any Degree Desired, by an Electric Heater In the Neck of the Envelope. Current Is Sent Up to the Balloon Basket from a Gasoline Engine-Dynamo Set Mounted on the Truck Below. Telephone Connection Between the Truck and the Observer Aloft Is Available. A Motor-Blower Drives Heated Air Into the Balloon Envelope.

Referring to the balloon in detail, we find that it is provided with an electric grid heater, and also a motor-driven blower and connecting tube, so that whenever the blower is operated, air is pumped up into the balloon envelope, the air passing thru the electric grid heater. The balloon bag is fitted with a suitable damper in the lower opening and a relief valve at the top in the usual manner, the relief valve being connected to the observer's basket by means of a small rope. When it is desired to descend, the observer may open the motor blower switch in the basket, and thus aid the hauling in of the balloon, for as the temperature of the air within the balloon bag falls the balloon naturally tends to descend toward the earth.

8,700,000 AMERICAN HOMES LIGHTED BY ELECTRICITY.

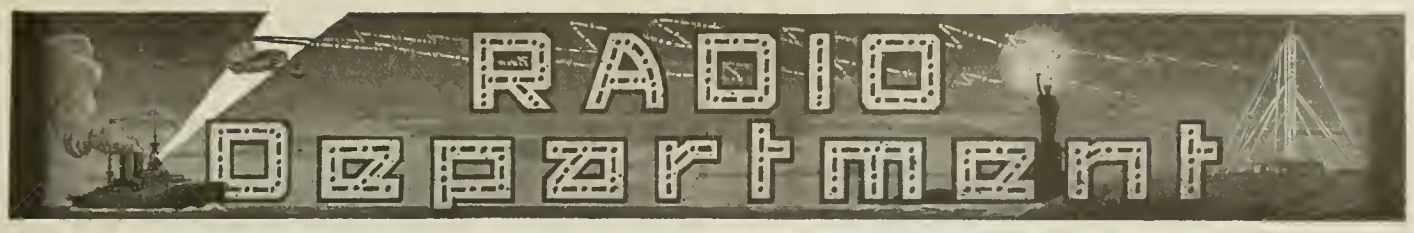
From the compilation made by the *Society for Electrical Development* it is shown that there are 20,689,000 families in this country, of which 7,000,000 have yearly incomes of $900 or more. However, the yearly average family income before the war was under $626.

Over 13,000,000 families are too poor, too illiterate, or otherwise unfitted to buy electrical goods. Over 8,700,000 homes are electrically lighted and 120,000,000 sockets contain Mazda lamps. In over 30,000,000 sockets are carbon lamps. It is estimated that 9,000,000 sockets are empty.

Homes lighted by other means, 15,000,000; some are wired but not connected up for service. Electric service is available in 10,613 communities of the United States, compared with 3,545 communities that are being served with gas.

ELECTRIC SEARCHLIGHTS.

Ranges of electrical searchlights vary from between one thousand to two thousand yards in foggy weather to ten thousand yards or more when the air is very clear. The average sea range is approximately six thousand yards, but there are cases on record where ships have been spotted at a distance of nine miles. These figures are based on a sixty-inch mirror and a twenty-thousand watt arc.



The Effect of Statics on Wireless Transmission

By NIKOLA TESLA

Written for the ELECTRICAL EXPERIMENTER

A FEW statements regarding these phenomena, in response to a request of the ELECTRICAL EXPERIMENTER, may be useful at the present time in view of the increasing interest and importance of the subject.

The commercial application of the art has led to the construction of larger transmitters and multiplication of their number, greater distances had to be covered and it became imperative to employ receiving devices of ever increasing sensitiveness. All these and other changes have cooperated in emphasizing the trouble and seriously impairing the reliability and value of the plants. To such a degree has this been the case that conservative business men and financiers have come to look upon this method of conveying intelligence as one offering but very limited possibilities, and the Government has deemed it advisable to assume control. This unfortunate state of affairs, fatal to enlistment of capital and healthful competitive development, could have been avoided had electricians not remained to this day under the spell of a delusive theory and had the practical exploiters of this advance not permitted enterprise to outrun technical competence.

With the publication of Dr. Heinrich Hertz's classical researches it was an obvious inference that the dark rays investigated by him could be used for signalling purposes, as those of light in heliography, and the first steps in this direction were made with his apparatus which, in 1896, was found capable of actuating receivers at a distance of a few miles. Three years prior to this, however, in lectures before the Franklin Institute and National Electric Light Association, I had described a wireless system radically opposite to the Hertzian in principle inasmuch as it depended on currents conducted thru the earth instead of on radiations propagated thru the atmosphere, presumably in straight lines.

The apparatus then outlined by me consisted of a transmitter comprising a primary circuit excited from an alternator or equivalent source of electrical energy and a high potential secondary resonant circuit, connected with its terminals to ground and to an elevated capacity, and a similar tuned receiving circuit including the operative device. On that occasion I exprest myself confidently on the feasibility of flashing in this manner not only signals to any terrestrial distance but transmitting power in unlimited amounts for all sorts of industrial purposes. The discoveries made and experimental results attained I made with a wireless power-plant erected in 1899, some of which were disclosed in the Century Magazine of June, 1900, and several U. S. patents subsequently granted to me have, I believe, borne-out strikingly my foresight. In the meantime the Hertzian arrangements were gradually modified, one feature after another being abandoned, so that now not a vestige of them can be found and my system of four tuned circuits has been universally adopted, not only in its fundamentals but in every detail as the "quenched sparks", "ticker", "tone wheel", high frequency and rotating field alternators, forms of discharges and mercury breaks, frequency changers, coils, condensers, regulating methods and devices, etc. This fact would give me supreme satisfaction were it not that the engineers, misinterpreting the nature of the effects, are making installments so defective in construction and mode of operation as to preclude the possibility of the great realization which might be brought within easy reach by proper application of the underlying principles and one of which—the most desirable at present—is the complete elimination of all static and other interference.

Tesla's Static Elimlnator, Patented and Used by Him over Twenty Years Ago. It Will Be Fully Described In an Early Issue of the Electrical Experimenter

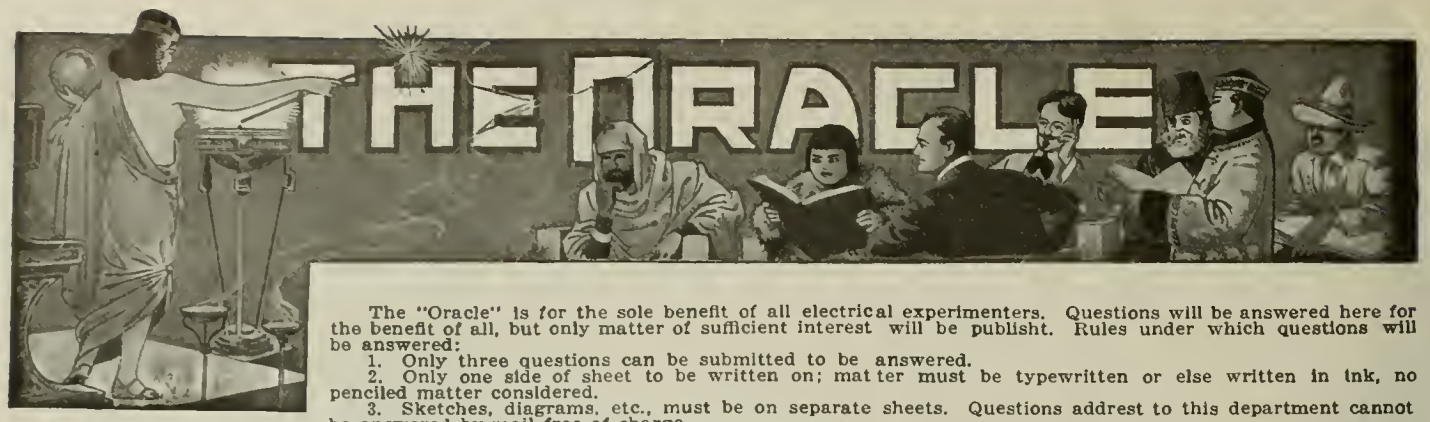
During the past few years several emphatic announcements have been made that a perfect solution of this problem had been discovered, but it was manifest from a casual perusal of these publications that the experts were ignoring certain truths of vital bearing on the question, and so long as this was the case no such claim could be substantiated. I achieved early success by keeping these steadily in mind and applying my efforts from the outset in the right and correct scientific direction.

I may contribute to the clearness of the subject in answering a question which I have been asked by the Editors of the ELECTRICAL EXPERIMENTER with reference to the report contained in the last issue, that signals had been received around the globe, an achievement the practicability of which I have fully demonstrated by experiment eighteen years ago.

The question is, how can Hertz waves be conveyed to such a distance in view of the curvature of the earth? A few words will be sufficient to show the absurdity of the prevailing opinion propounded in text books.

We are living on a conducting globe surrounded by a thin layer of insulating air, above which is a rarefied and conducting atmosphere. If the earth is represented by a sphere of 12½" radius, then the layer which may be considered insulating for high frequency currents of great tension is less than 1/64 of an inch thick. It is held that the Hertz waves, emanating from a transmitter, get to the distant receiver by successive reflections. The utter impossibility of this will be evident when it is shown by a simple calculation that the amount of

(*Continued on page* 658)



The "Oracle" is for the sole benefit of all electrical experimenters. Questions will be answered here for the benefit of all, but only matter of sufficient interest will be publisht. Rules under which questions will be answered:

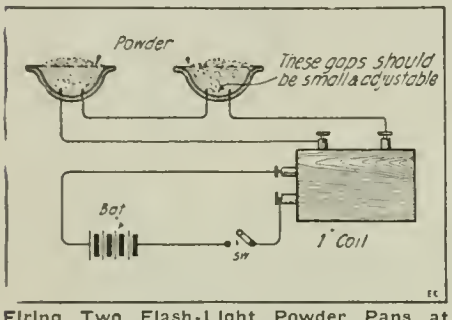
1. Only three questions can be submitted to be answered.
2. Only one side of sheet to be written on; matter must be typewritten or else written in ink, no penciled matter considered.
3. Sketches, diagrams, etc., must be on separate sheets. Questions addrest to this department cannot be answered by mail free of charge.
4. If a quick answer is desired by mail, a nominal charge of 25 cents is made for each question. If the questions entail considerable research work or intricate calculations a special rate will be charged. Correspondents will be informed as to the fee before such questions are answered.

FIRING TWO FLASH-LIGHT POWDER PANS SIMULTANEOUSLY.

(970) Fred Wheeler, Galt, Ont., Can., wants to know:

Q. 1. How to fire two or more flash-light pans simultaneously.

A. 1. For firing flash-light powder at



Firing Two Flash-Light Powder Pans at Once by Means of Spark Coil. Several Flashes May Be Ignited at Once.

two places simultaneously, we refer you to arrangement as per diagram. Use a spark coil and battery as indicated in diagram. Wire the two or more flash pans in series. Keep the spark gap in each pan small—1/16" gap is sufficient.

HOW TO TELL DYNAMO POLARITY.

(971) Paul Miles, Chicago, Ill., inquires:

Q. 1. How can the positive terminal of a small D. C. dynamo be determined?

A. 1. Off-hand we cannot tell you which is the positive brush. However, we advise you to make the following test: In a 50% solution of salt water put two wires connected to the dynamo, and note from which wire the most bubbles come off. This is the negative wire.

A 4-volt dynamo will give about 3 amperes. However, much depends upon the condition of the brushes (contact, pressure, etc.), and the condition of the batteries. We would advise you to refer to "Lessons in Practical Electricity and Magnetism," by Swoope, which can be purchased thru our Book Department for $2.25, postpaid.

SPEED CONTROL OF A.C. MOTORS.

(972) Hugh McPherson, Borden, Sask., Can., asks:

Q. 1. How can I control the speed of a 30 H.P. A.C. 3-phase motor?

A. 1. The speed of the 30 H.P. A.C. 3-phase motor can be regulated in several ways, some of the best of which are as follows:

The voltage applied to the motor is varied by a transformer from which several taps are brought out to a controller, thereby varying the speed. Again, by means of an induction regulator which consists of a primary and secondary winding, having an iron core with one of the windings so arranged as to allow of being varied thru 180 magnetic degrees.

The above methods are really best for single-phase service, while the following method is very good for the three-phase service: In this method the speed can be varied by changing the number of poles of the motor connected in the circuit by means of suitable switches or by varying the current by a suitable rheostat connected in the respective legs of the wound rotor circuits. This last method also applies to the single-phase system, wherein the current is varied by means of a rheostat.

LOOSE COUPLER AND DISTRIBUTED CAPACITY.

(973) C. W. Opert, Freeport, Ill., wishes to know:

Q. 1. Several points about making a loose coupler transformer for radio receiving circuits.

A. 1. In constructing a loose coupler, the best way to take the taps off is as follows: At the required part of the coil, punch a hole in the cardboard tube and bring about 18 inches of wire right thru this hole by looping the wire, and then pushing it thru. All that remains to be done now is to continue winding the coil until all the taps have been made.

We provide coils with dead-end switches in order to get rid of the *distributed capacity*. Distributed capacity is the capacity which exists between the turns of a helical coil, and for your benefit we refer you to an extensive article on this subject which was printed in the May, 1917, issue of this journal.

TESLA COIL FOR 2-INCH SPARK COIL.

(974) R. Conover, New York, N. Y., inquires of "The Oracle":

Q. 1. For data on a Tesla coil suitable for use on a 2-inch spark coil as an exciter.

A. 1. The ordinary Tesla coil, especially designed to work with a spark up to 2 inches on the primary side will do, and is briefly described as follows. The primary should consist of 14 turns No. 10 solid, rubber-covered copper wire in one layer on a spool 4½ inches in diameter, while the secondary consists of a coil 2¾ inches in diameter and 12 inches long, wound its full length with a layer No. 28 enamel wire.

This size of Tesla coil can be furnished by the leading companies who advertise in our magazine. It is best to use two one-pint Leyden jars connected in parallel or a one-quart Leyden jar.

The construction for a glass plate condenser for the above Tesla coil is as follows: Procure five glass plates 6x7x1/16" and four pieces of tin-foil 5x6 inches. The tin-foil should be placed between the five plates so that two ends of the tin-foil protrude from the sides of the glass. The size of the spark obtained from the above Tesla coil will be about ¾ to 1 inch and can be taken thru the body without any harm.

(*Continued on page* 648)

NIKOLA TESLA AND HIS INVENTIONS.

(*Continued from page* 615)

either a dreamer or, worse yet, crazy. The fact is the world does not understand you because you live in the next century. Moses was a great man, but the Bible teaches us that he was "heavy of tongue" and could not make himself understood. His brother therefore always spoke in his stead, announcing to his hearers what Moses had to say. Why not let the EXPERIMENTER be your brother? Why not let us translate your work into a language that the man in the street can readily understand? We have the knowledge and the technical training to do your inventions justice by means of graphic illustrations and wash drawings. The public does not want patent drawings or patent language. It wants pictures and plain English. You are a great inventor, but your 21st Century training prevents you from making yourself understood to a 20th Century public. My plan is to run one of your inventions every month, in plain English fully illustrated. That means that it will probably take over two years to deal with all of your more important inventions. At the end of this period the articles can be published in book form, a thing that does not exist at present. The plan is twofold. First, the world at large will at last understand the highly important work you have accomplished and will fully recognize you. Second, it will be of greatest benefit to Science, to whom your inventions will then not be the sealed book they are today."

Knowing that Tesla had in the past continuously refused similar offers of dozens of great publishers of this country as well as abroad, I was not at all sanguine of my own plan. Great was my surprise therefore, that he not only gave his consent, but he actually agreed to prepare each article personally with the Editors' collaboration.

Dr. Tesla wants it expressly understood that he is undertaking this great work chiefly to educate the young generation. He felt that he could not possibly reach such a large electrically trained young manhood, save thru the medium of the ELECTRICAL EXPERIMENTER. With its circulation above 100,000, all enthusiastic experimenters, Tesla feels that his greatest mission in life, namely, to assist our rising generation, will come near fulfillment.

Nikola Tesla's articles will therefore run serially every month in the ELECTRICAL EXPERIMENTER. The articles will be entitled: "My Inventions"—by Nikola Tesla. Every article will be entirely original; each will be illustrated with our own new illustrations and with such wash drawings as made this journal so successful. The first article will appear in our February number.

We wish to congratulate EXPERIMENTER readers for having obtained for them probably the greatest technical news feature of a generation. I caution you: *Expect much!*

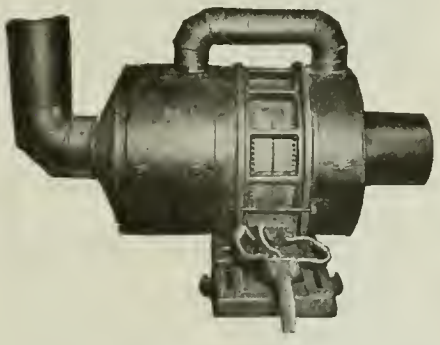
FARMERS AND ELECTRICITY.

Within the past three years the farmers of the United States have purchased one million automobiles and 100,000 tractors and innumerable pumping engines, and other devices run by electricity, according to widely publisht estimates. Farmers everywhere are rapidly advancing in the same direction, progress in labor-saving contrivances being phenomenal in this country. A motor does the churning; a motor runs the sewing machine and the washing machine. The rural telephone is invading country districts at the rate of many miles per day, and all farm machinery is being operated by the aid of tractors, which now haul the wagon and work the hay loader in the hay field. Next year, it is said, reapers and mowers in great numbers will be drawn by tractors.

DEVICE FOR PROTECTING ELECTRIC MOTORS.

A motor protection system which, it is claimed, does away with the trouble and expense of cleaning motors, has been devised and marketed. The usual type of installation, it is pointed out, in working out this system consists of casings which enclose each end of the motor and make it dust proof. A fan is attached to the end of the motor shaft, a dust separator, and an air intake pipe running to a clean air supply out of doors. When the motor is started, the fan draws in the cool, fresh air thru the dust separator and forces it against the rear end of the motor, thru the windings and out thru the laminations. Part of the air is forced thru a by-pass to the front hood so that the same action takes place on both sides of the motor.

As a result, it is pointed out that the motor is kept clean and has a large volume of cool, clean air constantly passing thru it which carries away the heat as fast as generated. Motor casings are provided with



Forced Air Cooling Apparatus Shown Installed on a Motor.

large doors to permit of a ready inspection of brushes, resistance, air-gap, bearings, and the like. The dust separator is also provided with doors so that the screens can be readily removed. The equipment can be applied to motors without moving them and requires a short time to install. Besides reducing the temperature and increasing the efficiency, the maker points out that the protection provided allows the carrying of a large overload without shortening the life of the motor and eliminates fire hazards.

DANIELS TELLS OF FOE RADIOS SCOUTS FOUND.

A telegram from Secretary of the Navy Daniels received by the Boy Scouts of America characterized them as "chivalrous young crusaders" because of their work during the war. It also disclosed that the Scouts, working on behalf of the Government, had discovered hundreds of illegal wireless plants.

Twenty-six of these plants were found in one day. A German alien, operating an underground radio station with a small New England river supplying the motive power, was taken into custody and interned. This plant was said to have been exchanging German Government messages between America and Berlin. Details of these scout activities are expected to be made public later.

THE EFFECT OF STATICS ON WIRELESS TRANSMISSION.

(*Continued from page 627*)

energy received, even if it could be collected in its totality, is infinitesimal and would not actuate the most sensitive instrument known were it magnified many million times. The fact is these waves have no perceptible influence on a receiver if situated at a much smaller distance. It should be remembered, moreover, that since the first attempts the wave lengths have been increased until those advocated by me were adopted, in which this form of radiation has been reduced to one-hillionth.

When a circuit, connected to ground and to an elevated capacity oscillates, two effects separate and distinct are produced; Hertz waves are radiated in a direction at right angles to the axis of symmetry of the conductor, *and simultaneously a current is passed through the earth.* The former propagates with the speed of light, the latter with a velocity proportionate to the cosecant of an angle which from the origin to the opposite point of the globe varies from zero to 180°. Expressed in words, at the start the speed is infinite and diminishes, first rapidly and then slowly until a quadrant is traversed when the current proceeds with the speed of light. From that region on the velocity gradually increases, becoming infinite at the opposite point of the globe. In a patent granted to me in April, 1905, I have summed up this law of propagation in the statement that the projections of all half waves on the axis of symmetry of movement are equal, which means that the successive half waves, tho of different length, cover exactly the same area. In the near future many wonderful results will be obtained by taking advantage of this fact.

There is a vast difference between these two forms of wave movement in their bearing on the transmission. The Hertz waves represent energy which is radiated and unrecoverable. The current energy, on the other hand, is preserved and can be recovered theoretically, at least, in its entirety. If the experts will free themselves from the illusions under which they are laboring, they will find that to overcome static disturbances all that is needed is a properly constructed transmitter and receiver without any additional devices or preventives. I have, however, devised several forms of apparatus eliminating statics even in the present defective wireless installations in which they are magnified many times. Such a form of instrument which I have used successfully is shown in the annexed photograph. These phenomena have been studied by me for a number of years and I have found that there are nine or ten different causes tending to intensify them, and in due course. I shall give a full description of the various improvements I have made, in the ELECTRICAL EXPERIMENTER. For the present I would only point out that in order to perfectly eliminate the static interference, it is indispensable to redesign the whole wireless apparatus as now employed. The sooner this is understood the better it will be for the further evolution of the Art.

A means of making use of the electric magnet under water has been devised in Japan, and it promises to be of great assistance in locating sunken vessels, to recover which salvage operations on a big scale are expected after the war.

With the aid of special oxygen masks airplane experts believe that air fighters will be able to carry on battles five miles above the earth.

ONE READER'S EXPERIENCE WITH DR. ABRAMS' THOUGHT TRANSFERENCE THEORY.

As our reader's will recollect, we suggested in the September issue in connection with the article therein entitled "Popular Demonstration of Thought Transference and Other Phenomena," by Dr. Albert Abrams, that they write us as to what success they have attained in conducting any of the experiments outlined by Dr. Abrams in this little known realm of science, and we are pleased to give herewith the views of Mr. J. W. White of Brooklyn, N. Y., Mr. White having witnest a number of these tests as conducted by Dr. Abrams himself, when visiting San Francisco several years ago. Furthermore, Mr. White, who is in the electrical business in New York City, and a thoroly wide-awake student of electrical and allied matters, had the satisfaction of taking part in some of the experiments in Dr. Abrams' laboratory, and his views as given below are those of an unprejudiced and unbiased student.

Many people undoubtedly who have read the article in question have tried, unsuccessfully perhaps, to obtain results by *unipolar currents*, according to the theory of Dr. Abrams, such as for instance where the "percipient" or person interpreting the thought transference signal or message is connected to another person or body which forms the exciting point in the unipolar (single wire) circuit.

Here, for example, is what Mr. White experienced, and in this connection it is well to remember that the high professional standing of Dr. Abrams in the medical and scientific fields precludes all doubt of any fake or misrepresented reactions or phenomena, however little we may as yet know as to the exact mode in which such phenomena take place. First Dr. Abrams placed Mr. White in a separate laboratory room and gave him a permanent steel bar magnet, which as we all know has a *North* and *South* pole at the alternate ends. The Doctor instructed Mr. White to present either magnet pole as he might elect to the steam radiator in the room, when he would be able to tell in his instrument laboratory just which end of the magnet he had presented. According to the theory of Dr. Abrams, the action here was as follows: That the electronic discharge from the magnet, even when held a short distance from the radiator, charged the metal piping system, and this particular discharge past along thru the radiator and metal piping to the laboratory where an instrument or a human substitute for the instrument was connected by *one wire* to another radiator connected to the system. In this connection it is interesting to note that Dr. Abrams usually prefers to employ some delicate human reflex, such as the heart or stomach reflex, for indicating when one of these extremely minute electric currents arise, and which agents he claims are many *hundred thousand times* more sensitive to minute currents than are the most delicate scientific instruments such as galvanometers, etc. To sum up this experiment, Dr. Abrams was able to tell quickly just which magnet pole Mr. White had presented to the radiator, not making a single miss in twenty tests.

One of the most astounding phases of this particular experiment was when the Doctor informed Mr. White that it was not at all necessary that he present the magnet to the radiator, so as either to touch it or approach close up to it, but that he could determine which pole of the magnet the investigator was *thinking of* if he would but lay it on the floor and *concentrate his mind*

on one of the poles. This experiment was checked up by a considerable number of tests, and Dr. Abrams was able to tell the pole concentrated on in Mr. White's mind each time.

One of the experiments which will interest our readers very greatly, especially those who read the article referred to in the September issue, was that where Mr. White became the "percipient." To show the effect of the electric currents in the body, Dr. Abrams had a strong man placed in a separate laboratory, several rooms away from where Mr. White was located, and both this man and Mr. White were connected by a *single* copper wire. A number of heavy weights were placed in the room with the strong man. The percipient—Mr. White—had attached to one of his fingers a pulse detector of these minute electronic currents, as devised by Dr. Abrams, comprising a small rubber tube strapt to the finger; this tube being connected by means of a rubber tube with a small pneumatic chamber attached to a pivoted arm, the free end of which carried an electric contact for opening and closing a signal circuit. The contacts on this instrument were conected with a battery and an electric signaling bell. This pulse indicator was connected and acted in the same way, upon the receipt of each electronic wave or current, as the straw pulse needle indicator described in the article referred to.

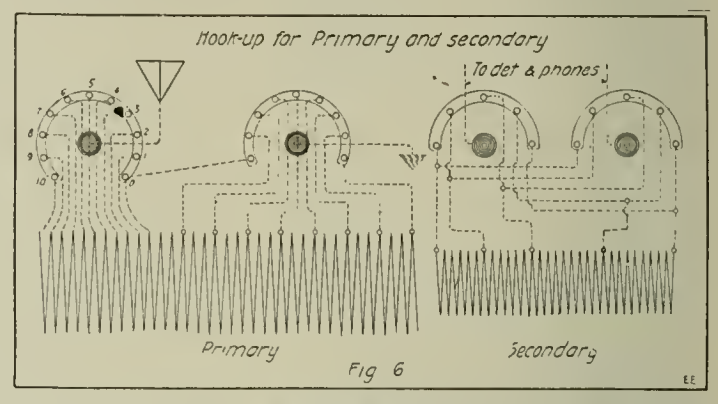
This is what happened every time the strong man lifted the weights in the distant part of the laboratory buildings: An electronic current apparently shot along the wire and acted to cause a heart reflex in the percipient's (Mr. White's) body, which manifested itself at the pulse, and in turn this action repeated itself thru the rubber tube attached to the finger, thus causing the pneumatic diafram chamber to vibrate and move the pivot arm attached to it, which in turn caused the electric signal bell to ring each time a weight was lifted by the "agent."

Probably some of the most remarkable tests which Mr. White personally saw performed by Dr. Abrams were those where he was enabled to differentiate between different disease germs, and in some cases even the disease affecting a patient over a telephone or other wire. For some of these and other tests Dr. Abrams has devised a very interesting instrument to take the place of the stomach reflex, thus doing away with the necessity of a "live" percipient. This instrument comprises an aluminum cylinder covered at one end with a tightly stretched diafram of goldbeater's skin. The metallic bell or rather shell of this instrument is connected to the single unipolar terminal used in this arrangement, instead of connecting the wire to a human percipient or interpreter, and whenever an electronic current was received over the wire, the tone of the bell, as produced by striking the diafram with a small hammer, is caused to be either resonant or full, or else dull, according to the reaction taking place. Moreover, disease germs such as tuberculosis, cancer, and pneumonia have their own vibration period or wave length, according to his most remarkable work, "New Concepts in Diagnosis and Treatment." He outlines forms of wireless tuning aparatus comprising condensers, tuning coils, etc., for the purpose of measuring the exact wave length or vibration index of these electronic currents as they are received over a telephone or other wire and interpreted by the instrument just described, or by recourse to a human percipient employing the stomach or other reflex. The stomach reflex is one in which the percussion sound given by the stomach when struck with the fingers over that portion of the body is dulled when an electronic current is received.

were purchased from a hardware store. These are glass drawer knobs and have a brass shell into which the glass knob is cemented; also a screw is fitted into the end. Five of these are needed. The switch blade is cut from a piece of springy brass or nickel. Cut two pieces three inches long and taper down one end (see Fig. 5). The other end must be made to fit the knob. A hole is drilled into this end and the blade is soldered to the brass cup; bend the contact end as shown. Also cut two pieces one and one-half inches long for the secondary switches and fasten in the same way and to the fifth knob solder the hand of a clock.

The switch points are common upholsterer's nails with the brass tops and small washers to fit the under side. After the wire has been drawn thru a hole drilled in the cabinet for it, it is twisted around the nail and the loop thus formed pushed far down into the hollow of the cup of the nail. A small amount of flux and a piece of solder about one-quarter the size of a split pea is placed into the cup which is held hollow upward. A hot iron is now touched to the nail, and the solder will melt flush and make an excellent connection. The washer is now slipt over the nail and the nail driven in place. The washers are not essential but make the heads of the switch point protrude more. (Fig. 5.)

The method of varying the coupling is by a cable and drum arrangement. Rack and pinion methods need accurate workmanship for them to operate correctly, so this novel home-made method was devised. After the clock hand has been soldered to No. 5 knob, a twenty-four inch (circumference) wooden wheel is fastened to the screw of this knob. This wheel is locked in place and a bearing is made to fit the other end of the screw, so that there will be a fairly good axle and bearings formed, one bearing being the front panel. A bent piece of brass will answer for the other end. A piece of leather is fastened in such a way as to cause friction against the wooden wheel. A piece of cord is nailed to the wheel and wound around the groove; the cord passing over a small pulley and secured to the screw-eye on the upper end of the secondary (see Fig. 4).



Hook-Up of Primary and Secondary Windings On Vertical Coupler. Note That Secondary Switching Circuit Permits of Reversing the Polarity of the Circuit.

ASSEMBLY

Along the mid-line of the panel and four and eight inches up from the bottom, respectively, drill two holes to fit the screws of the switches. Above each of these drill two smaller holes for wires which will go to antenna and ground. Draw the flexible wires thru; solder to switch blade (Fig. 5) and put switch in place. Place a spring on the under side of switch to keep it tight. Describe an arc with each switch and using about two-thirds of a complete circle for the arrangement of switch points, divide them equally into the area thus allowed. Drill holes for the wires of the switch points, solder to switch points as already described and hammer into place. Then seventeen inches from the bottom and two inches from the mid-line each way, drill holes for the switches of the secondary. Mount the sixteen switch points in place as per diagram for connections.

Put the top on the cabinet with the bolts (eye-bolts) for slider rods and tighten the rods; finally put on back. The diagram of the assembled coil is shown in Fig. 7.

There are many advantages of this type cabinet, as it is both compact, inexpensive and neat. It does not allow dust to settle between the windings and prevents the entrance of other foreign matter. One complete turn of the coupling knob will change the coupling completely. Accurate tuning of the primary is worked out to a very fine extent and the novel arrangement of the secondary tuning will be seen to have many merits, as any portion of the coil may be used and the direction of current may also be reversed. Often the coupling will not have to be changed in order to vary the secondary, as both switches may be moved and so bring another portion of the coil into play.

With a galena detector stand and using a "radiocite" crystal, this outfit cannot be beaten and other stations were brought in that never were heard before. This may have been due to the excellency of the crystal, but the coil has something to do with it, in my estimation.

SOLAR ENGINE USES SUN'S ENERGY.

(Continued from page 607)

Messrs. Shuman, Boys, and Ackerman, engineered and built a large solar energy plant at Meadi on the Nile, Egypt. This plant developed 100 h.p. The total area of sunshine collected was 13,269 square feet. The maximum pounds of steam generated was 12 pounds per 100 square feet of sunshine, or the equivalent, to *183 square feet per brake horsepower.* The best hour's run developed, at atmospheric pressure, 1,442 pounds of steam. Hence (allowing 22 pounds steam per brake horsepower) the maximum output for an hour was 55.5 horsepower (about ten times better than any previous results). This means *63 brake horsepower per acre of land occupied by the plant.* Moreover, no marked reduction in the horsepower produced was noticeable in the early hours of the morning or in the late hours of the afternoon.

The temperature of the sun, as aforementioned, has been calculated to be about 6,000 degrees centigrade. Several authorities point out that this terrific heat therefore precludes any possibility of the sun being a molten mass in the process of combustion. It has been thought recently by many to be a great mass of matter possessing to a remarkable degree radio-activity akin to radium. Helmholtz proposed that the sun could keep on producing energy at its present rate by accounting for same on the basis of a slight annual shrinkage in its size. From observations and measurements

of this heavenly body made from year to year it has been computed that the age of the sun would, on the shrinkage basis, be 17,000,000 years.

The radiant energy received from the sun at the outer surface of the earth's atmosphere is equivalent to *7,300 horsepower per acre.* Of this about 70 per cent. or, roughly speaking, 5,000 horsepower per acre, is transmitted thru the atmosphere to the land surface proper of the earth, at noon on a clear day. Lesser amounts, of course, are received in the early morning and late afternoon, owing to the greater thickness thru which the energy must pass.

Relative to the basis upon which solar energy is calculated for the earth's surface, this is generally made, it may be said, on the "solar constant," as it is termed, ascertained from 696 tests conducted by the Smithsonian Institute of Washington, in various parts of the world, which resulted in accepting 1.93 calories per square centimeter per minute, equal to *7.12 British thermal units per square foot per minute.* This is an average value, all things considered.

Only about three-fifths of the solar radiation produce any impression on the earth, and it is only the radiant energy which falls on some material body that is converted into heat. The best body for this conversion having been ascertained to be a dead black one.

"ODD PHOTO" CONTEST.

(*Continued from page* 616)

as to work the strings. Fourthly, it was indoors on a cloudy day. I simply guest at the time—about 25 seconds for each exposure (double exposure) and let 'er go at that. The streaks are the strings; the lenses were between the two strings. I didn't expect it to be any good at all. So if you have any extra dollars flying around, send one out to Iowa. Fred Wagner,
Burlington, Iowa.

NOVEL PHOTO OF CITY AND LIGHTNING AT NIGHT.

The photo I submit is a picture of a city at night, taken from a high mountain nearby. The object of taking the picture was to "snap" the lightning.

Rob't Sullivan, Canon City, Colo.

AT LAST—A PHOTO OF "BALL LIGHTNING."

Speaking of "Odd Photos" or something for the "bug" to worry about, I think I have it here, in the form of two actual photographs, either of which contain any kind of lightning one would want, i.e., *chain, ribbon* or *ball.*

These photos were taken about six months ago (Pardon the selfishness) on the same night and about five minutes apart, during a very damaging electrical disturbance in this locality.

I may be wrong in my conception of the impression on the right side of photo No. 1 (the upper left photo) being *ball lightning,* but would suppose it to be such. This picture is an exposure of 30 seconds. There was no artificial light of any kind in front of the camera. This phenomenon was not perceptible to the eye—or at least was not observed.

If this be ball lightning we then know that ball lightning is of an oscillating or pulsating nature, as is evident from the path taken by the ball. Possibly this is a potential of one sign seeking its affinity or opposite potential sign, in order that it may neutralize. Following the path of the ball it comes in at the base of the ribbon discharge at the left, whence it travels straight across, almost parallel to the wires in the background, then it comes to rest in the upper right hand corner. It now slowly follows an irregular path with a few stops and makes its exit into the heavens, no doubt to join its patiently waiting other half.

Photo No. 2 (lower center) is a 3 minute exposure, during which time the camera was moved once but very slightly, as you see from the double print of the chimneys in the background. In this picture will be seen innumerable paths of the light ball where it has traveled at various speeds.

L. E. Church, Bailesville, Okla.

EXPERIMENTS IN RADIO-ACTIVITY.

(*Continued from page* 636)

radio-active study. It is thought unnecessary here to give further experiments in this phase of the subject as they will suggest themselves to the reader. It is an intensely interesting subject and the reader will derive both beneficial knowledge and pleasure from his experiments. There are many other properties of these substances besides their ionizing power which will be taken up in later articles.

(*To be continued*)

BUILDING A 3-INCH SPARK STATIC MACHINE.

(*Continued from page* 633)

should reach the comb and thus prevent the escape of the electricity before it reaches the metal points.

An iron ring placed on the conductor heightens its capacity. This consists of an iron wire bent in a circle and then well insulated with paper, which is later varnished with shellac.

If the handle of the machine is turned towards the combs, electric sparks can be drawn from the small ball attached to the end of the brass wire holding the comb.

It is unnecessary to explain the uses of Leyden jars and other apparatus which can be used in connection with this machine, as any "Physics book," under the heading of "Electricity," describes a number of them.

THE CITY OF SPLENDID NIGHT.

(*Continued from page* 623)

footed torch-bearers led the way. None of them, proud souls, ever saw their doorways in fullest beauty, the beauty that is electric, that softens rude prominences while it throws a lustrous, enchanting glow over fine design and decoration.

The "City of Splendid Night" forever calls me to fresh delights. I go the way of a side street at the beckon of a light and, anon, find myself before the stately pile of a church, mirrored against the sky by the guardian pillar of radiance that stands before it. Later I come upon a green park bordered with electric jewels. Here I seat myself and watch the trees play tag with beams of electric brilliance.

Beginning: "My Inventions," by Nikola Tesla

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ELECTRICAL EXPERIMENTER

SCIENCE AND INVENTION

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THE TESLA WIRELESS LIGHT

SEE PAGE 692

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EDITORIAL

The New Wireless

IT will come as a profound shock to all wireless enthusiasts, scientific and amateur alike, that their present-day notions on wireless are totally erroneous and not based upon actual facts. For years we clung to the theory that a wireless message radiates from the aerial wires of the sending station and speeds over the surface of the earth thru the ether towards the receiving station. We thought that we were sending out pure Hertzian waves from our transmitters. We thought that we received these waves over the aerial wires of our receiving station. All of these theories are wrong and will be relegated shortly into the past along with the early notion that the earth stood still, while sun, moon and stars revolved around it.

Remain only the physical facts that we did send and did receive messages without wires—but they are not sent by means of pure Hertz waves, nor do they go by way of the ether as radiations.

In a highly illuminating article printed elsewhere in this issue, Nikola Tesla explodes all of our present orthodox views as to wireless propagation and makes it clear that the earth is the sole medium thru which our wireless impulses travel, in the form of true conduction. Particularly does this hold true for long distance messages: Here we are sending out a compound impulse three quarters of which is a galvanic current, traveling thru the conducting earth, the other quarter or less is in the form of Hertz waves, going by way of the ether. This explains why we can send signals to airplanes and vice versa; but even here we probably have to do not with pure Hertz waves: it is almost certain that we have capacity-inductive effects as well.

Tesla maintaining that there can be no long distance effects by radiations transmitted thru the ether, but rather only by currents thru the earth, it follows that in his opinion all our radio apparatus is designed and operated faultily. Indeed, this is not a brand new idea of the famous inventor. He has been preaching it ever since he took out his first patents and described his system in 1893—long before Marconi thought of wireless But he was preaching to a stone deaf scientific world.

But how simple it all becomes when we stop to apply a little reason and logic to Tesla's claims. For instance, we can send radio impulses three to five times as far over salt water as over land. Why? Simply because the impulses go *thru* the water, which is a much better conductor than earth alone. If we were sending pure Hertzian waves, why do we connect one wire at both sending and receiving station to the ground? Hertz never dreamt of such a thing. If you are still unconvinced that the earth is the chief medium of transmission, disconnect your ground wires entirely and try to send and receive. Now you may work with Hertz waves, but the distances you can bridge will be pitifully small.

Already Tesla's logic is filtering into our radio scientists' minds. *All the big stations are beginning to scrap their towers and aerial wires, at least for receiving. They now bury their "aerial" wires in the ground,* and lo! they can receive signals twice as far as before. Incredible, but it is being done every day. And—wonders upon wonders—how we will laugh at our present and past blindness—*the static interference is practically gone* the minute we pull our aerial wires down and bury them! Static Electricity? There never was a reason for having the bugaboo, for there is no "static" in the ground.

But Tesla goes much farther. In time he will show the world wireless power transmission effected *not by ether waves but by currents thru the earth,* which is a first rate conductor. Like all big things, the problem is simple. At some point on the globe he will erect a station powerful enough to charge the whole earth with electricity—and keep it charged. To do this we need about 10,000 kilowatts. Then at *any* point on the globe the current can be tapt by means of suitable apparatus. Like a bell ringing transformer, *connected* to your supply line, no current is consumed unless you close the secondary circuit. Tesla's world wireless works just that way. *No current is consumed till it is tapt at the distant receiving station.*

H. GERNSBACK.

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Famous Scientific Illusions

By NIKOLA TESLA

Written specially for the Electrical Experimenter

In this original and revolutionizing discussion, Nikola Tesla gives us something really new to think about. First—Does the moon rotate on its axis? Second—Is the Franklin pointed lightning rod correct in theory and operation? Third—Do wireless signals fly thru space by means of so-called Hertzian waves in the ether, or are they propagated thru the earth at prodigious velocity by means of earth-bound oscillations? World-famous conundrums these—questions which have been answered in many ways by some of the greatest scientists. Dr. Tesla explains these three predominant scientific fallacies in a masterly way, so that everyone can understand them.

THE human brain, with all its wonderful capabilities and power, is far from being a faultless apparatus. Most of its parts may be in perfect working order, but some are atrophied, undeveloped or missing altogether. Great men of all classes and professions—scientists, inventors, and hard-headed financiers—have placed themselves on record with impossible theories, inoperative devices, and unrealizable schemes. It is doubtful that there could be found a single work of any one individual free of error. There is no such thing as an infallible brain. Invariably, some cells or fibers are wanting or unresponsive, with the result of impairing judgment, sense of proportion, or some other faculty. A man of genius eminently practical, whose name is a household word, has wasted the best years of his life in a visionary undertaking. A celebrated physicist was incapable of tracing the direction of an electric current according to a childishly simple rule. The writer, who was known to recite entire volumes by heart, has never been able to retain in memory and recapitulate in their proper order the words designating the colors of the rainbow, and can only ascertain them after long and laborious thought, strange as it may seem.

Our organs of reception, too, are deficient and deceptive. As a semblance of life is produced by a rapid succession of inanimate pictures, so many of our perceptions are but trickery of the senses, devoid of reality. The greatest triumphs of man were those in which his mind had to free itself from the influence of delusive appearances. Such was the revelation of Buddha that self is an illusion caused by the persistence and continuity of mental images; the discovery of Copernicus that, contrary to all observation, this planet rotates around the sun; the recognition of Descartes that the human being is an automaton, governed by external influence and the idea that the earth is spherical, which led Columbus to the finding of this continent. And tho the minds of individuals supplement one another and science and experience are continually eliminating fallacies and misconceptions, much of our present knowledge is still incomplete and unreliable. We have sophisms in mathematics which cannot be disproved. Even in pure reasoning, free of the shortcomings of symbolic processes, we are often arrested by doubt which the strong-

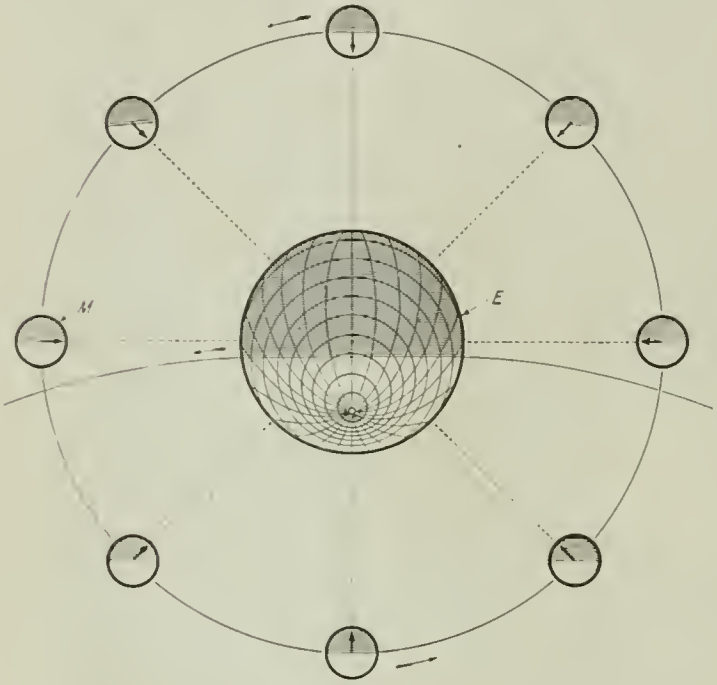


Fig. 1

It Is Well Known That the Moon, M., Always Turns the Same Face Toward the Earth, E, as the Black Arrows Indicate. The Parallel Rays From the Sun Illuminate the Moon In Its Successive Orbital Positions as the Unshaded Semi-circles Indicate. Bearing This In Mind, Do You Believe That the Moon Rotates on Its Own Axis?

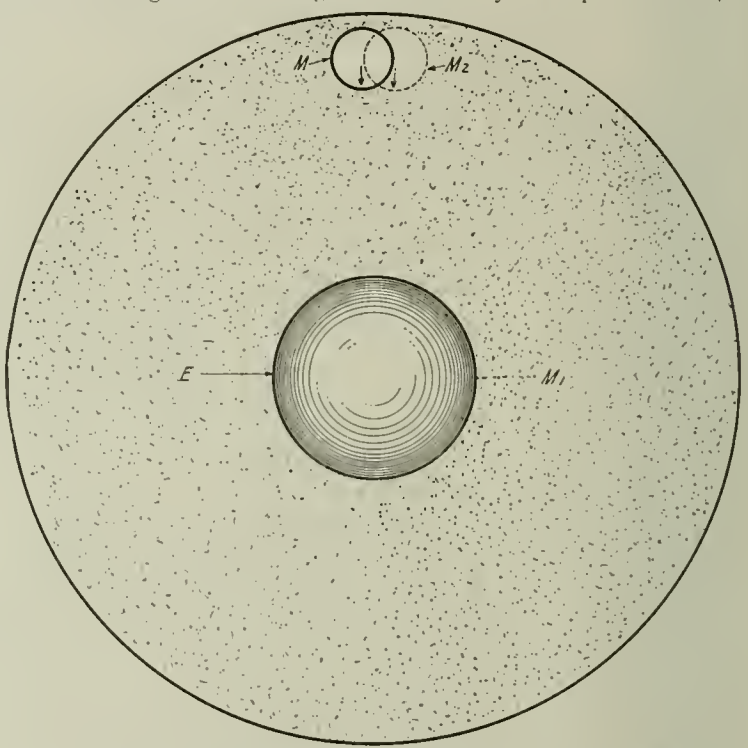


Fig. 2.—Tesla's Conception of the Rotation of the Moon, M, Around the Earth, E; the Moon, In This Demonstration Hypothesis, Being Considered as Embedded In a Solid Mass, M_1. If, As Commonly Believed, the Moon Rotates, This Would Be Equally True For a Portion of the Mass M_2, and the Part Common to Both Bodies Would Turn Simultaneously In "Opposite" Directions.

FOR over a century and a half the whole world, educated and otherwise, thought that the moon revolved around its axis. Nikola Tesla in the present highly instructive article disproves that theory and will convince scientists and all others alike that the moon does no such thing.

For thousands of years it was thought that the sun and stars revolved around the earth and all kinds of experimental proofs were furnished to substantiate this theory. The illustrious Galileo thought different, and everyone today knows that the earth revolves around the sun.

So it is with Tesla's discovery. Tesla also, in the second part of the present paper, shows us that the ancient and time-worn theory advanced by Benjamin Franklin as to the lightning conductor is not substantially correct as viewed by latter day science. It will come as a shock even to our professors that the lightning rod actually aids the lightning in hitting the building. The reason is that the lightning rod helps in ionizing (making conductive) the surrounding air.

Mr. Tesla has devised a lightning conductor with no points, and there is no doubt whatsoever that his theory is right. Scientists the world over will acknowledge this very shortly.

In a third section of the same paper Tesla explodes still another popular delusion, viz., that wireless waves follow the curvature of the earth when messages are transmitted, let us say from a point in the United States to a point in Europe. In his revolutionary arguments, supported by facts as well as by logic, Tesla shows why the currents do not travel around the earth but directly thru it. In other words, Tesla maintains that wireless communication is accomplished ONLY thru the medium of the earth itself. His contention seems very sound. If it were not so, let every wireless station, commercial or otherwise, do away with its ground connection. None could then operate as is well known, except perhaps over very limited distances.

Mr. Tesla's present article will arouse world-wide comment due to the revolutionary philosophy contained therein. We are sure our readers will appreciate Mr. Tesla's most timely and illuminating article on this hut little understood subject.

est intelligences have been unable to dispel. Experimental science itself, most positive of all, is not unfailing.

In the following I shall consider three exceptionally interesting errors in the interpretation and application of physical phenomena which have for years dominated the minds of experts and men of science.

I. The Illusion of the Axial Rotation of the Moon.

It is well known since the discovery of Galileo that the moon, in travelling thru space, always turns the same face towards the earth. This is explained by stating that, while passing once around its mother-planet the lunar globe performs just one revolution on its axis. The spinning motion of a heavenly body must necessarily undergo modifications in the course of time, being either retarded by resistances internal or external, or accelerated owing to shrinkage and other causes. An unalterable rotational velocity thru all phases of planetary evolution is manifestly impossible. What wonder, then, that at this very instant of its long existence our satellite should revolve exactly so, and not faster or slower. But many astronomers have accepted as a physical fact that such rotation takes place. It does not, but only appears so; it is an illusion, a most surprising one, too.

I will endeavor to make this clear by reference to Fig. 1, in which E represents the earth and M the moon. The movement thru space is such that the arrow, firmly attached to the latter, always occupies the position indicated with reference to the earth. If one imagines himself as looking down on the orbital plane and follows the motion he will become convinced that the moon *does* turn on its axis as it travels around. But in this very act the observer will have deceived himself. To make the delusion complete let him take a washer similarly marked and supporting it rotatably in the center, carry it around a stationary object, constantly keeping the arrow pointing towards the latter. Tho to his bodily vision the disk will revolve on its axis, such movement does not exist. He can dispel the illusion at once by holding the washer fixedly while going around. He will now readily see that the supposed axial rotation is only apparent, the impression being produced by successive changes of position in space.

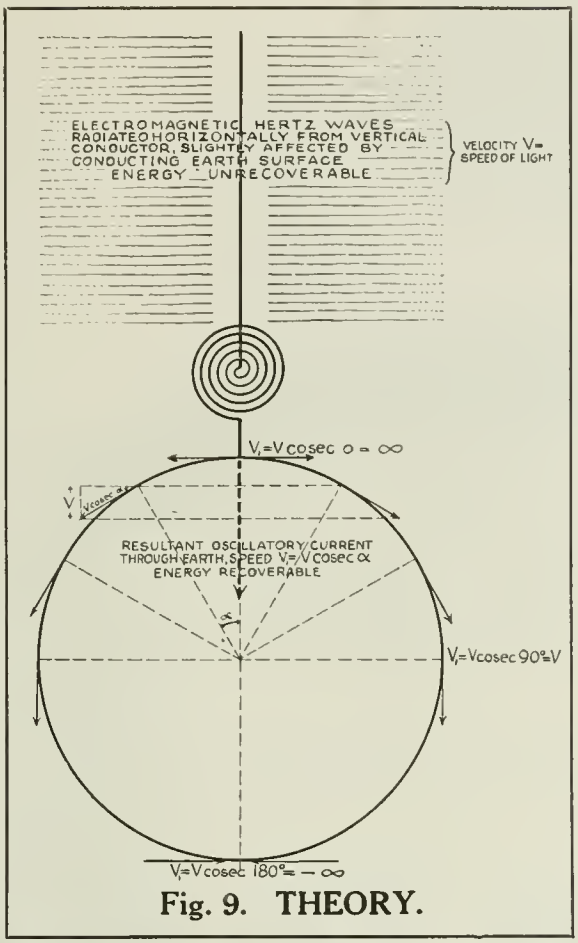
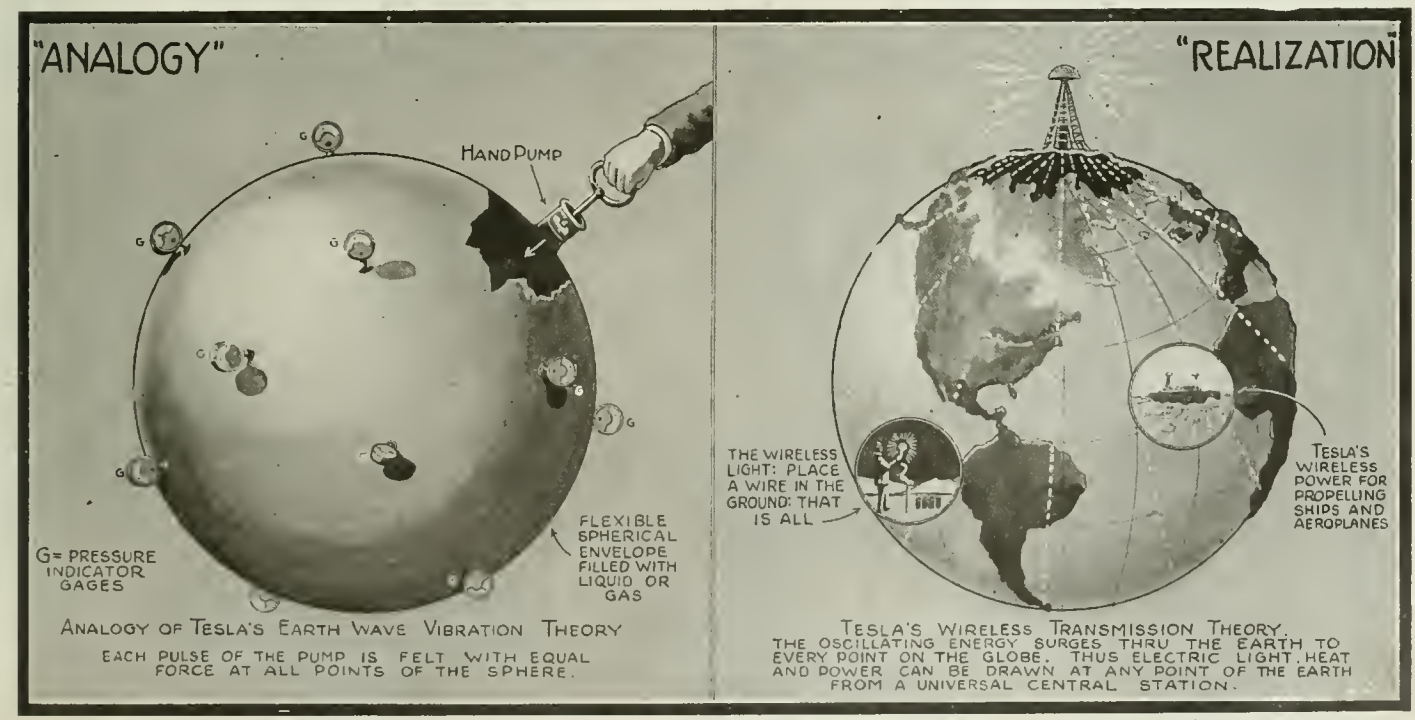


Fig. 9. THEORY.

But more convincing proofs can be given that the moon does not, and cannot revolve on its axis. With this object in view attention is called to Fig. 2, in which both the satellite, M, and earth, E, are shown embedded in a solid mass, M_1 (indicated by stippling) and supposed to rotate so as to impart to the moon its normal translatory velocity. Evidently, if the lunar globe could rotate as commonly believed, this would be equally true of any other portion of mass M_1, as the sphere M_2, shown in dotted lines, and then the part common to both bodies would have to turn *simultaneously in opposite directions.* This can be experimentally illustrated in the manner suggested by using instead of one, two overlapping rotatable washers, as may be conveniently represented by circles M and M_2, and carrying them around a center as E, so that the plain and dotted arrows are always pointing towards the same center. No further argument is needed to demonstrate that the two gyrations cannot co-exist or even be pictured in the imagination and reconciled in a purely abstract sense.

The truth is, the so-called "axial rotation" of the moon is a phenomenon deceptive alike to the eye and mind and devoid of physical meaning. It has nothing in common with real mass revolution characterized by effects positive and unmistakable. Volumes have been written on the subject and many erroneous arguments advanced in support of the notion. Thus, it is reasoned, that if the planet did *not* turn on its axis it would expose the whole surface to terrestrial view; as only one-half is visible, it *must* revolve. The first statement is true but the logic of the second is defective, for it admits of only one alternative. The conclusion is not justified as the same appearance can also be produced in another way. The moon does rotate, not on its own, **but about an axis passing thru the center of the earth, the true and only one.**

The unfailing test of the spinning of a mass is, however, the existence of



Tesla's World-Wide Wireless Transmission of Electrical Signals, As Well As Light and Power, Is Here Illustrated In Theory, Analogy and Realization. Tesla's Experiments With 100 Foot Discharges At Potentials of Millions of Volts Have Demonstrated That the Hertz Waves Are Infinitesimal In Effect and Unrecoverable; the Recoverable Ground Waves of Tesla Fly "Thru the Earth". Radio Engineers Are Gradually Beginning to See the Light and That the Laws of Propagation Laid Down by Tesla Over a Quarter of a Century Ago Form the Real and True Basis of All Wireless Transmission To-Day.

energy of motion. The moon is not possest of such *vis viva*. If it were the case then a revolving body as M1 would contain mechanical energy other than that of which we have experimental evidence. Irrespective of this so exact a coincidence between the axial and orbital periods is, in itself, immensely improbable for this is not the permanent condition towards which the system is tending. Any axial rotation of a mass left to itself, retarded by forces external or internal, must cease. Even admitting its perfect control by tides the coincidence would still be miraculous. But when we remember that most of the satellites exhibit this peculiarity, the probability becomes infinitestimal.

Three theories have been advanced for the origin of the moon. According to the oldest suggested by the great German philosopher Kant, and developed by Laplace in his monumental treatise "Mécanique Céleste", the planets have been thrown off from larger central masses by centrifugal force. Nearly forty years ago Prof. George H. Darwin in a masterful essay on tidal friction furnished mathematical proofs, deemed unrefutable, that the moon had separated from the earth. Recently this established theory has been attacked by Prof. T. J. J. See in a remarkable work on the "Evolution of the Stellar Systems", in which he propounds the view that centrifugal force was altogether inadequate to bring about the separation and that all planets, including the moon, have come from the depths of space and have been captured. Still a third hypothesis of unknown origin exists which has been examined and commented upon by Prof. W. H. Pickering in "Popular Astronomy of 1907", and according to which the moon was torn from the earth when the later was partially solidified, this accounting for the continents which might not have been formed otherwise.

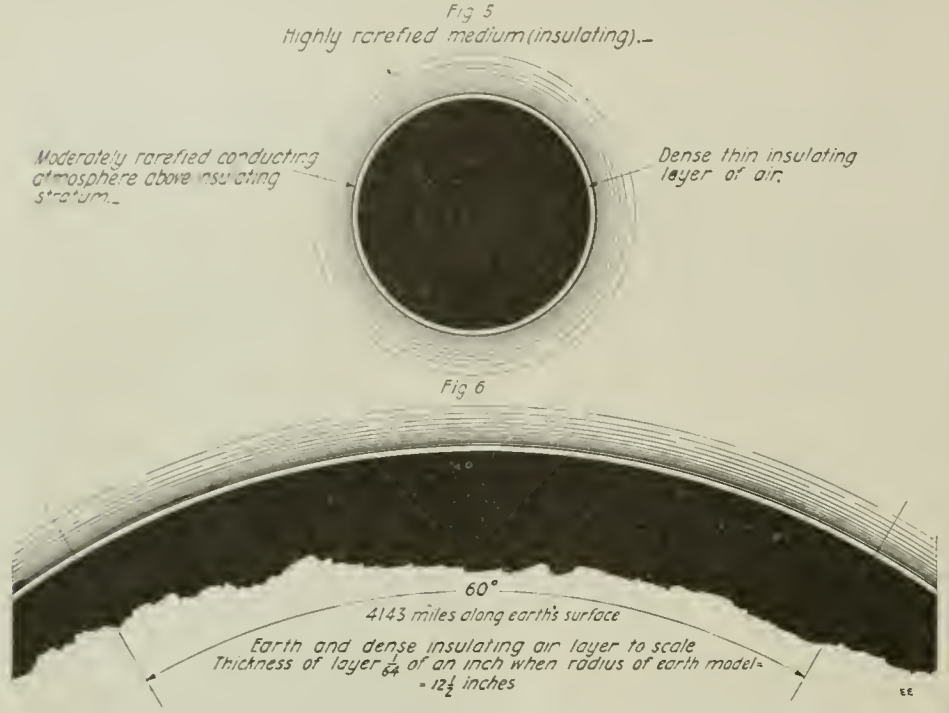
Undoubtedly planets and satellites have originated in both ways and, in my opinion, it is not difficult to ascertain the character of their birth. The following conclusions can be safely drawn:

1. A heavenly body thrown off from a larger one cannot rotate on its axis. The mass, rendered fluid by the combined action of heat and pressure, upon the reduction of the latter immediately stiffens, being at the same time deformed by gravitational pull. The shape becomes permanent upon cooling and solidification and the smaller mass continues to move about the larger one as tho it were rigidly connected to it except for pendular swings or librations due to varying orbital velocity. Such motion precludes the possibility of axial rotation in the strictly physical sense. The moon has never spun around as is well demonstrated by the fact that the most precise measurements have failed to show any measurable flattening in form.

2. If a planetary body in its orbital movement turns the same side towards the central mass this is a positive proof that it has been separated from the latter and is a true satellite.

3. A planet revolving on its axis in its passage around another cannot have been thrown off from the same but must have been captured.

Fig 5



A Section of the Earth and Its Atmospheric Envelope Drawn to Scale. It Is Obvious That the Hertzian Rays Cannot Traverse So Thin a Crack Between Two Conducting Surfaces For Any Considerable Distance, Without Being Absorbed, Says Dr. Tesla, in Discussing the Ether Space Wave Theory.

II. The Fallacy of Franklin's Pointed Lightning-Rod.

The display of atmospheric electricity has since ages been one of the most marvelous spectacles afforded to the sight of man. Its grandeur and power filled him with fear and superstition. For centuries he attributed lightning to agents god-like and supernatural and its purpose in the scheme of this universe remained unknown to him. Now we have learned that the waters of the ocean are raised by the sun and maintained in the atmosphere delicately suspended, that they are wafted to distant regions of the globe where electric forces assert themselves in upsetting the sensitive balance and causing precipitation, thus sustaining all organic life. There is every reason to hope that man will soon be able to control this life-giving flow of water and thereby solve many pressing problems of his existence.

Atmospheric electricity became of special scientific interest in Franklin's time. Faraday had not yet announced his epochal discoveries in magnetic induction but static frictional machines were already generally used in physical laboratories. Franklin's powerful mind at once leaped to the conclusion that frictional and atmospheric electricity were identical. To our present view this inference appears obvious, but in his time the mere thought of it was little short of blasphemy. He investigated the phenomena and argued that if they were of the same nature then the clouds could be drained of their charge exactly as the ball of a static machine, and in 1749 he indicated in a publisht memoir how this could be done by the use of pointed metal rods.

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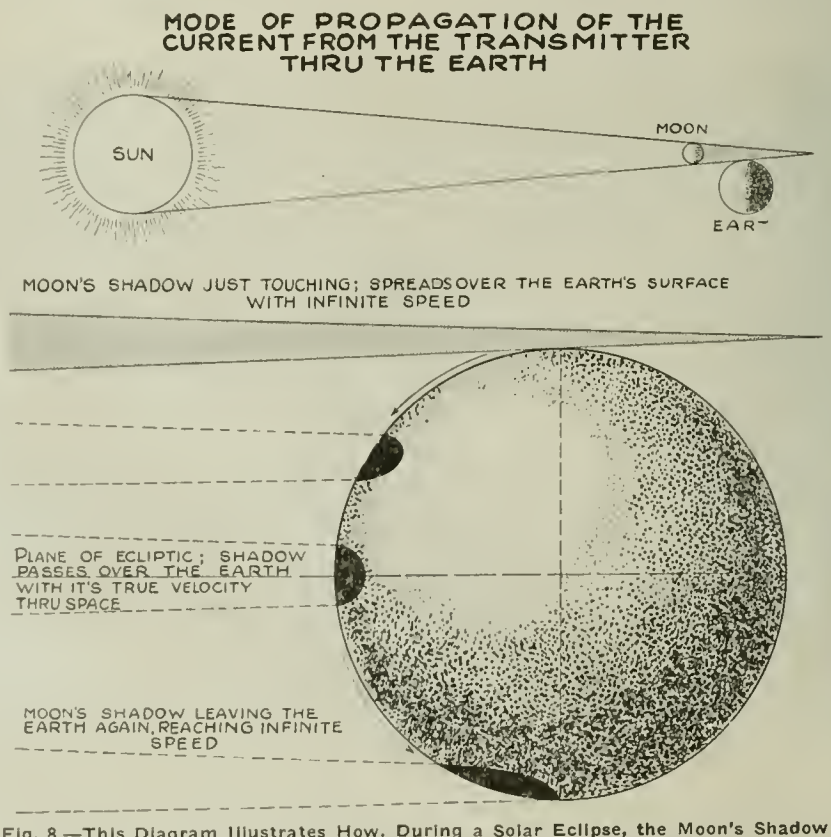


Fig. 8.—This Diagram Illustrates How, During a Solar Eclipse, the Moon's Shadow Passes Over the Earth With Changing Velocity, and Should Be Studied In Connection With Fig. 9. The Shadow Moves Downward With Infinite Velocity at First, Then With Its True Velocity Thru Space, and Finally With Infinite Velocity Again.

My Inventions

By Nikola Tesla

1. MY EARLY LIFE

THE progressive development of man is vitally dependent on invention. It is the most important product of his creative brain. Its ultimate purpose is the complete mastery of mind over the material world, the harnessing of the forces of nature to human needs. This is the difficult task of the inventor who is often misunderstood and unrewarded. But he finds ample compensation in the pleasing exercises of his powers and in the knowledge of being one of that exceptionally privileged class without whom the race would have long ago perished in the bitter struggle against pitiless elements.

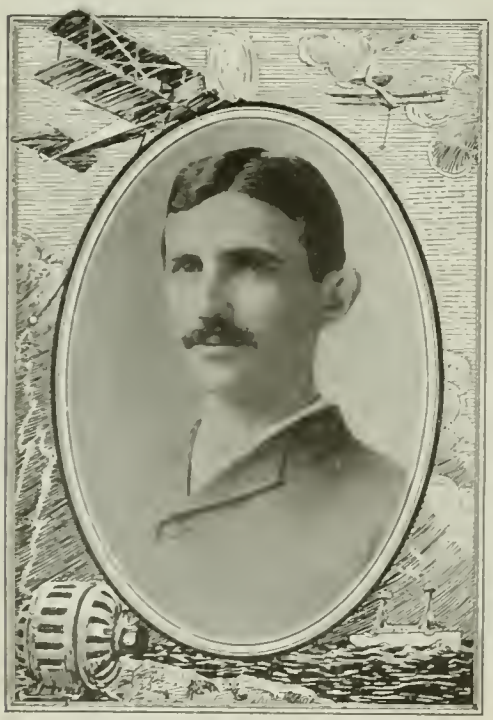
Speaking for myself, I have already had more than my full measure of this exquisite enjoyment, so much that for many years my life was little short of continuous rapture. I am credited with being one of the hardest workers and perhaps I am, if thought is the equivalent of labor, for I have devoted to it almost all of my waking hours. But if work is interpreted to be a definite performance in a specified time according to a rigid rule, then I may be the worst of idlers. Every effort under compulsion demands a sacrifice of life-energy. I never paid such a price. On the contrary, I have thrived on my thoughts.

In attempting to give a connected and faithful account of my activities in this series of articles which will be presented with the assistance of the Editors of the ELECTRICAL EXPERIMENTER and are chiefly addrest to our young men readers, I must dwell, however reluctantly, on the impressions of my youth and the circumstances and events which have been instrumental in determining my career.

Our first endeavors are purely instinctive, promptings of an imagination vivid and undisciplined. As we grow older reason asserts itself and we become more and more systematic and designing. But those early impulses, tho not immediately productive, are of the greatest moment and may shape our very destinies. Indeed, I feel now that had I understood and cultivated instead of suppressing them, I would have added substantial value to my bequest to the world. But not until I had attained manhood did I realize that I was an inventor.

This was due to a number of causes. In the first place I had a brother who was gifted to an extraordinary degree—one of those rare phenomena of mentality which biological investigation has failed to explain. His premature death left my parents disconsolate. We owned a horse which had been presented to us by a dear friend. It was a magnificent animal of Arabian breed, possest of almost human intelligence, and was cared for and petted by the whole family, having on one occasion saved my father's life under remarkable circumstances. My father had been called one winter night to perform an urgent duty and while crossing the mountains, infested by wolves, the horse became frightened and ran away, throwing him violently to the ground. It arrived home bleeding and

Nikola Tesla at the Age of 23.
From An Unpublished Photograph.

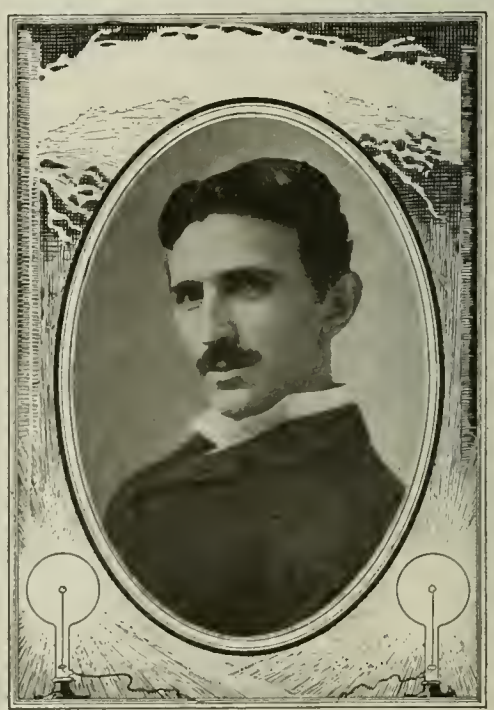


Mr. Tesla at the Age of 29.

HOW does the world's greatest inventor invent? How does he carry out an invention? What sort of mentality has Nikola Tesla? Was his early life as commonplace as most of ours? What was the early training of one of the World's Chosen? These, and many other very interesting questions are answered in an incomparable manner by Nikola Tesla himself in this, his first article.

In his autobiography, treating mainly on his early youth, we obtain a good insight into the wonderful life this man has led. It reads like a fairy tale, which has the advantage of being true. For Tesla is no common mortal. He has led a charmed life—struck down by the pest, the cholera and what not—given up by doctors at least three times as dead—we find him at sixty, younger than ever. But—read his own words. You have never read the like before.

—Editor.



Mr. Tesla at the Age of 39.

exhausted, but after the alarm was sounded immediately dashed off again, returning to the spot, and before the searching party were far on the way they were met by my father, who had recovered consciousness and remounted, not realizing that he had been lying in the snow for several hours. This horse was responsible for my brother's injuries from which he died. I witnest the tragic scene and altho fifty-six years have elapsed since, my visual impression of it has lost none of its force. The recollection of his attainments made every effort of mine seem dull in comparison.

Anything I did that was creditable merely caused my parents to feel their loss more keenly. So I grew up with little confidence in myself. But I was far from being considered a stupid boy, if I am to judge from an incident of which I have still a strong remembrance. One day the Aldermen were passing thru a street where I was at play with other boys. The oldest of these venerable gentlemen—a wealthy citizen—paused to give a silver piece to each of us. Coming to me he suddenly stopt and commanded, "Look in my eyes." I met his gaze, my hand outstretched to receive the much valued coin, when, to my dismay, he said, "No, not much, you can get nothing from me, you are too smart." They used to tell a funny story about me. I had two old aunts with wrinkled faces, one of them having two teeth protruding like the tusks of an elephant which she buried in my cheek every time she kist me. Nothing would scare me more than the prospect of being hugged by these as affectionate as unattractive relatives. It happened that while being carried in my mother's arms they asked me who was the prettier of the two. After examining their faces intently, I answered thoughtfully, pointing to one of them, "This here is not as ugly as the other."

Then again, I was intended from my very birth for the clerical profession and this thought constantly opprest me. I longed to be an engineer but my father was inflexible. He was the son of an officer who served in the army of the Great Napoleon and, in common with his brother, professor of mathematics in a prominent institution, had received a military education but, singularly enough, later embraced the clergy in which vocation he achieved eminence. He was a very erudite man, a veritable natural philosopher, poet and writer and his sermons were said to be as eloquent as those of Abraham a Sancta-Clara. He had a prodigious memory and frequently recited at length from works in several languages. He often remarked playfully that if some of the classics were lost he could restore them. His style of writing was much admired. He penned sentences short and terse and was full of wit and satire. The humorous remarks he made were always peculiar and characteristic. Just to illustrate, I may mention one or two instances. Among the help there was a cross-eyed man called Mane, employed to do work around the farm. He was chopping wood one day. As he swung the axe my father, who stood nearby and felt very uncomfortable, cautioned him, "For God's sake, Mane, do not strike at what you are looking but at what you intend to hit." On another occasion he was taking out for a drive a friend who carelessly permitted his costly fur coat to rub on the carriage wheel. My father reminded him of it saying, "Pull in your coat, you are ruining my tire." He had the odd habit of talking to himself and would often carry on an animated conversation and indulge in heated argument, changing the tone of his voice. A casual listener might have sworn that several people were in the room.

Altho I must trace to my mother's influence whatever inventiveness I possess, the training he gave me must have been helpful. It comprised all sorts of exercises—as, guessing one another's thoughts, discovering the defects of some form or expression, repeating long sentences or performing mental calculations. These daily lessons were intended to strengthen memory and reason and especially to develop the critical sense, and were undoubtedly very beneficial.

My mother descended from one of the oldest families in the country and a line of inventors. Both her father and grandfather originated numerous implements for household, agricultural and other uses. She was a truly great woman, of rare skill, courage and fortitude, who had braved the storms of life and past thru many a trying experience. When she was sixteen a virulent pestilence swept the country. Her father was called away to administer the last sacraments to the dying and during his absence she went alone to the assistance of a neighboring family who were stricken by the dread disease. All of the members, five in number, succumbed in rapid succession. She bathed, clothed and laid out the bodies, decorating them with flowers according to the custom of the country and when her father returned he found everything ready for a Christian burial. My mother was an inventor of the first order and would, I believe, have achieved great things had she not been so remote from modern life and its multifold opportunities. She invented and constructed all kinds of tools and devices and wove the finest designs from thread which was spun by her. She even planted the seeds, raised the plants and separated the fibers herself. She worked indefatigably, from break of day till late at night, and most of the wearing apparel and furnishings of the home was the product of her hands. When she was past sixty, her fingers were still nimble enough *to tie three knots in an eyelash.*

There was another and still more important reason for my late awakening. In my boyhood I suffered from a peculiar affliction due to the appearance of images, often accompanied by strong flashes of light, which marred the sight of real objects and interfered with my thought and action. They were pictures of things and scenes which I had really seen, never of those I imagined. When a word was spoken to me the image of the object it designated would present itself vividly to my vision and sometimes I was quite unable to distinguish whether what I saw was tangible or not. This caused me great discomfort and anxiety. None of the students of psychology or physiology whom I have consulted could ever explain satisfactorily these phenomena. They seem to have been unique altho I was probably predisposed as I know that my brother experienced a similar trouble. The theory I have formulated is that the images were the result of a reflex action from the brain on the retina under great excitation. They certainly were not hallucinations such as are produced in diseased and anguished minds, for in other respects I was normal and composed. To give an idea of my distress, suppose that I had witnest a funeral or some such

(*Continued on page* 743)

NIKOLA TESLA
THE MAN
By H. Gernsback

THE door opens and out steps a tall figure—over six feet high—gaunt but erect. It approaches slowly, stately. You become conscious at once that you are face to face with a personality of a high order. Nikola Tesla advances and shakes your hand with a powerful grip, surprising for a man over sixty. A winning smile from piercing light blue-gray eyes, set in extraordinarily deep sockets, fascinates you and makes you feel at once at home.

You are guided into an office immaculate in its orderliness. Not a speck of dust is to be seen. No papers litter the desk, everything just so. It reflects the man himself, immaculate in attire, orderly and precise in his every movement. Drest in a dark frock coat, he is entirely devoid of all jewelry. No ring, stickpin, or even watch-chain can be seen.

Tesla speaks—a very high almost falsetto voice. He speaks quickly and very convincingly. It is the man's voice chiefly which fascinates you.

As he speaks you find it difficult to take your eyes off his own. Only when he speaks to others do you have a chance to study his head, predominant of which is a very high forehead with a bulge between the eyes—the neverfailing sign of an exceptional intelligence. Then the long, well-shaped nose, proclaiming the scientist.

How does this man, who has accomplished such a tremendous work, keep young and manage to surprise the world with more and more new inventions as he grows older? How does this youth of sixty, who is a professor of mathematics, a great mechanical and electrical engineer and the greatest inventor of all times, keep his physical as well as remarkable mental freshness?

To begin with, Tesla, who is by birth a Serbian, comes from a long-lived hardy race. His family tree abounds with centenarians. Accordingly, Tesla—barring accidents—fully expects to be still inventing in A. D. 1960.

But the chief reason for his perpetual youth is found in his gastronomical frugality. Tesla has learned the great fundamental truth that most people not only eat all of their bodily ills, but actually eat themselves to death by either eating too much or else by food that does not agree with them.

When Tesla found out that tobacco and black coffee interfered with his physical well-being, he quit both. This is the simple daily menu of the great inventor:

Breakfast: One to two pints of warm milk and a few eggs, prepared by himself—yes, he is a bachelor!

Lunch: None whatsoever, as a rule.

Dinner: Celery or the like, soup, a single piece of meat or fowl, potatoes and one other vegetable; a glass of light wine. For dessert, perhaps a slice of cheese, and invariably a big raw apple. And that's all.

Tesla is very fussy and particular about his food: he eats very little, but what he does eat must be of the very best. And he knows, for outside of being a great inventor in science he is an accomplished cook who has invented all sorts of savory dishes.

His only vice is his generosity. The man who, by the ignorant onlooker has often been called an idle dreamer, has made over a million dollars out of his inventions—and spent them as quickly on new ones. But Tesla is an idealist of the highest order and to such men money itself means but little.

Famous Scientific Illusions

(*Continued from page 694*)

The earliest trials were made by Dalibrand in France, but Franklin himself was the first to obtain a spark by using a kite, in June, 1752. When these atmospheric discharges manifest themselves today in our wireless station we feel annoyed and wish that they would stop, but to the man who discovered them they brought tears of joy.

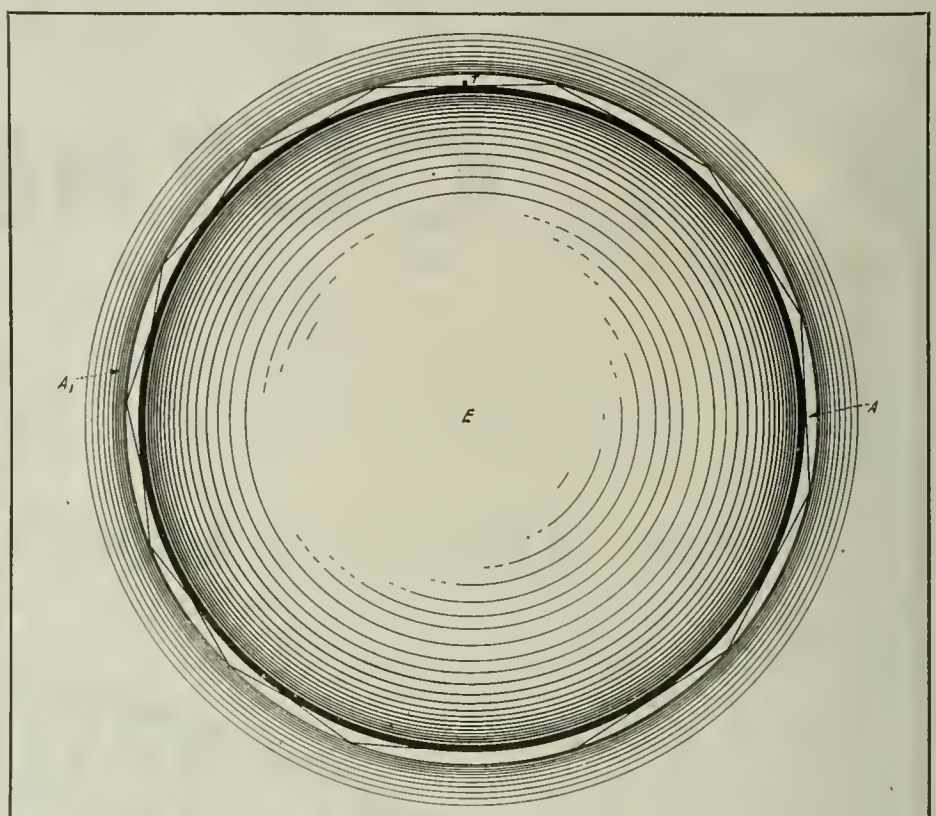


Fig. 7

The Theory Has Been Seriously Advanced and Taught that the Radio Ether Wave Oscillations Pass Around the Earth by Successive Reflections, as Here Shown. The Efficiency of Such a Reflector Cannot be more than 25 Per Cent; the Amount of Energy Recoverable in a 12,000-mile Transmission being but One Hundred and Fifteen Billionth Part of One Watt, with 1,000 Kilowatts at the Transmitter.

The lightning conductor in its classical form was invented by Benjamin Franklin in 1755 and immediately upon its adoption proved a success to a degree. As usual, however, its virtues were often exaggerated. So, for instance, it was seriously claimed that in the city of Piatermaritzburg (capital of Natal, South Africa) no lightning strokes occurred after the pointed rods were installed, altho the storms were as frequent as before. Experience has shown that just the opposite is true. A modern city like New York, presenting innumerable sharp points and projections in good contact with the earth, is struck much more often than equivalent area of land. Statistical records, carefully compiled and publisht from time to time, demonstrate that the danger from lightning to property and life has been reduced to a small percentage by Franklin's invention, but the damage by fire amounts, nevertheless, to several million dollars annually. It is astonishing that this device, which has been in universal use for more than one century and a half, should be found to involve a gross fallacy in design and construction which impairs its usefulness and may even render its employment hazardous under certain conditions.

For explanation of this curious fact I may first refer to Fig. 3, in which s is a metallic sphere of radius r, such as the capacity terminal of a static machine, provided with a sharply pointed pin of length h, as indicated. It is well known that the latter has the property of quickly dissipating the accumulated charge into the air. To examine this action in the light of present knowledge we may liken electric potential to temperature. Imagine that sphere s is heated to T degrees and that the pin or metal bar is a perfect conductor of heat so that its extreme end is at the same temperature T. Then if another sphere of larger radius, r_1, is drawn about the first and the temperature along this boundary is T_1, it is evident that there will be between the end of the bar and its surrounding a difference of temperature $T - T_1$, which will determine the outflow of heat. Obviously, if the adjacent medium was not affected by the hot sphere this temperature difference would be greater and more heat would be given off. Exactly so in the electric system. Let q be the quantity of the charge, then the sphere—and owing to its great conductivity also the pin—will be at the potential $\frac{q}{r}$. The medium around the point of the pin will be at the potential $\frac{q}{r_1} = \frac{q}{r+h}$ and, consequently, the difference $\frac{q}{r} - \frac{q}{r+h} = \frac{qh}{r(r+h)}$. Suppose now that a sphere S of much larger radius $R = nr$ is employed containing a charge Q this difference of potential will be, analogously $\frac{Qh}{R(R+h)}$. According to elementary principles of electro-statics the potentials of the two spheres s and S will be equal if $Q = nq$ in which case $\frac{Qh}{R(R+h)} =$

(*Continued on page 730*)

FAMOUS SCIENTIFIC ILLUSIONS.

(*Continued from page 728*)

$\frac{nqh}{nr(nr+h)} = \frac{qh}{r(nr+h)}$. Thus the difference of potential between the point of the pin and the medium around the same

Fig. 4. Tesla Explains the Fallacy of the Franklin Pointed Lightning Rod, Here Illustrated, and Shows that Usually Such a Rod Could Not Draw Off the Electricity in a Single Cloud in Many Years. The Density of the Dots Indicates the Intensity of the Charges.

will be smaller in the ratio $\frac{r+h}{nr+h}$ when the large sphere is used. In many scientific tests and experiments this important observation has been disregarded with the result of causing serious errors. Its significance is that the behavior of the pointed rod entirely depends on the linear dimensions of the electrified body. Its quality to give off the charge may be entirely lost if the latter is very large. For this reason, all points or projections on the surface of a conductor of such vast dimensions as the earth would be quite ineffective were it not for other influences. These will be elucidated with reference to Fig. 4, in which our artist of the Impressionist school has emphasized Franklin's notion that his rod was drawing electricity from the clouds. If the earth were not surrounded by an atmosphere which is generally oppositely charged it would behave, despite all its irregularities of surface, like a polished sphere. But owing to the electrified masses of air and cloud the distribution is greatly modified. Thus in Fig. 4, the positive charge of the cloud induces in the earth an equivalent *opposite* charge, the density at the surface of the latter diminishing with the cube of the distance from the static center of the cloud. A brush discharge is then formed at the point of the rod and the action Franklin anticipated takes place. In addition, the surrounding air is ionized and rendered conducting and, eventually, a bolt may hit the building or some other object in the vicinity. The virtue of the pointed end to dissipate the charge, which was uppermost in Franklin's mind is, however, infinitesimal. *Careful measurements show that it would take many years before the electricity stored in a single cloud of moderate size would be drawn off or neutralized thru such a lightning conductor.* The grounded rod has the quality of rendering harmless most of the strokes it receives, tho occasionally the charge is diverted with damaging results. But, what is very important to note, it invites danger and hazard on account of the fallacy involved in its design. The sharp point which was thought advantageous and indispensable to its operation, is really a defect detracting considerably from the practical value of the device. I have produced a much improved form of lightning protector characterized by the employment of a terminal of considerable area and large radius of curvature which makes impossible undue density of the charge and ionization of the air.* *These protectors act as quasi-repellents and so far have never been struck tho exposed a long time.* Their safety is experimentally demonstrated to greatly exceed that invented by Franklin. By their use property worth millions of dollars which is now annually lost, can be saved.

III. The Singular Misconception of the Wireless.

To the popular mind this sensational advance conveys the impression of a single invention but in reality it is an art, the successful practise of which involves the employment of a great many discoveries and improvements. I viewed it as such when I undertook to solve wireless problems and it is due to this fact that my insight into its underlying principles was clear from their very inception.

In the course of development of my induction motors it became desirable to operate them at high speeds and for this purpose I constructed alternators of relatively

*Refer to the October, 1918, issue of this journal wherein Dr. Tesla's new form of non-pointed lightning rod was fully described and illustrated.

(*Continued on page 732*)

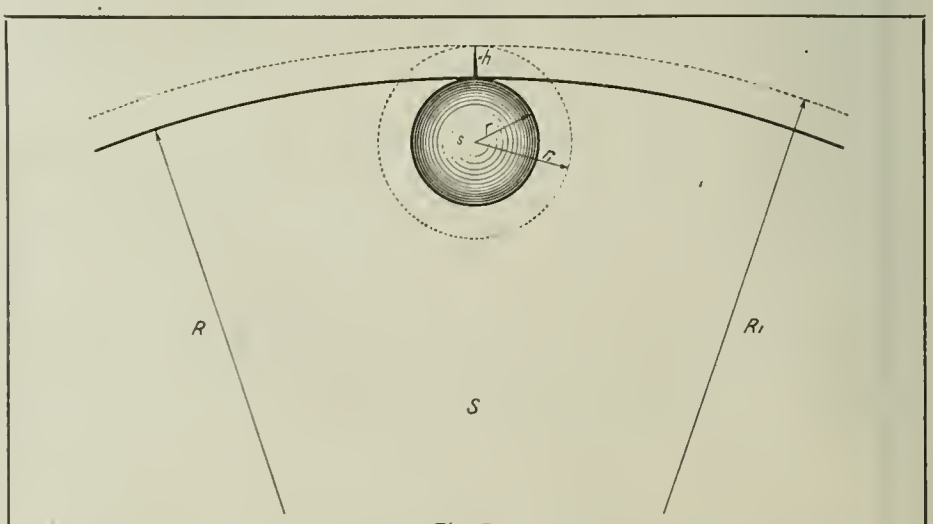


Fig. 3

Diagram Used to Explain the Fallacy of the Franklin Pointed Lightning Rod, and an Analogy Whereby the Author Shows In a Clear Manner How the Charged Sphere May for Illustration be Considered as Heated to a High Degree, and the Heat Allowed to Escape at a Known Rate

FAMOUS SCIENTIFIC ILLUSIONS

(*Continued from page 730*)

high frequencies. The striking behavior of the currents soon captivated my attention and in 1889 I started a systematic investigation of their properties and the possibilities of practical application. The first gratifying result of my efforts in this direction was the transmission of electrical energy thru *one wire* without return, of which I gave demonstrations in my lectures and addresses before several scientific bodies here and abroad in 1891 and 1892. During that period, while working with my oscillation transformers and dynamos of frequencies up to 200,000 cycles per second, the idea gradually took hold of me that the earth might be used in place of the wire, thus dispensing with artificial conductors altogether. The immensity of the globe seemed an unsurmountable obstacle but after a prolonged study of the subject I became satisfied that the undertaking was rational, and in my lectures before the Franklin Institute and National Electric Light Association early in 1893 I gave the outline of the system I had conceived. In the latter part of that year, at the Chicago World's Fair, I had the good fortune of meeting Prof. Helmholtz to whom I explained my plan, illustrating it with experiments. On that occasion I asked the celebrated physicist for an expression of opinion on the feasibility of the scheme. He stated unhesitatingly that it was practicable, provided I could perfect apparatus capable of putting it into effect but this, he anticipated, would be extremely difficult to accomplish.

I resumed the work very much encouraged and from that date to 1896 advanced slowly but steadily, making a number of improvements the chief of which was my system of *concatenated tuned circuits* and method of regulation, now universally adopted. In the summer of 1897 Lord Kelvin happened to pass thru New York and honored me by a visit to my laboratory where I entertained him with demonstrations in support of my wireless theory. He was fairly carried away with what he saw but, nevertheless, condemned my project in emphatic terms, qualifying it as something impossible, "an illusion and a snare." I had expected his approval and was pained and surprised. But the next day he returned and gave me a better opportunity for explanation of the advances I had made and of the true principles underlying the system I had evolved. Suddenly he remarked with evident astonishment: "Then you are not making use of Hertz waves?" "Certainly not," I replied, "*these are radiations.* No energy could be economically transmitted to a distance by any such agency. In my system the process is one of *true conduction* which, theoretically, can be effected at the greatest distance without appreciable loss." I can never forget the magic change that came over the illustrious philosopher the moment he freed himself from that erroneous impression. The skeptic who would not believe was suddenly transformed into the warmest of supporters. He parted from me not only thoroly convinced of the scientific soundness of the idea but strongly exprest his confidence in its success. In my exposition to him I resorted to the following mechanical analogues of my own and the Hertz wave system.

Imagine the earth to be a bag of rubber filled with water, a small quantity of which is periodically forced in and out of the same by means of a reciprocating pump, as illustrated. If the strokes of the latter are effected in intervals of more than one hour and forty-eight minutes, sufficient for the transmission of the impulse thru the whole mass, the entire bag will expand and contract and corresponding movements will be imparted to pressure gauges or movable pistons with the same intensity, irrespective of distance. By working the pump faster, shorter waves will be produced which, on reaching the opposite end of the bag, may be reflected and give rise to stationary nodes and loops, but in any case, the fluid being incompressible, its inclosure perfectly elastic, and the frequency of oscillations not very high, the energy will be economically transmitted and very little power consumed so long as no work is done in the receivers. This is a crude but correct representation of my wireless system in which, however, I resort to various refinements. Thus, for instance, the pump is made part of a resonant system of great inertia, enormously magnifying the force of the imprest impulses. The receiving devices are similarly conditioned and in this manner the amount of energy collected in them vastly increased.

The Hertz wave system is in many respects the very opposite of this. To explain it by analogy, the piston of the pump is assumed to vibrate to and fro at a terrific rate and the orifice thru which the fluid passes in and out of the cylinder is reduced to a small hole. There is scarcely any movement of the fluid and almost the whole work performed results in the production of radiant heat, of which an infinitesimal part is recovered in a remote locality. However incredible, it is true that

the minds of some of the ablest experts have been from the beginning, and still are, obsest by this monstrous idea, and so it comes that the true wireless art, to which I laid the foundation in 1893, has been retarded in its development for twenty years. This is the reason why the "statics" have proved unconquerable, why the wireless shares are of little value and why the Government has been compelled to interfere.

We are living on a planet of well-nigh inconceivable dimensions, surrounded by a layer of insulating air above which is a rarefied and conducting atmosphere (Fig. 5). This is providential, for if all the air were conducting the transmission of electrical energy thru the natural media would be impossible. My early experiments have shown that currents of high frequency and great tension readily pass thru an atmosphere but moderately rarefied, so that the insulating stratum is reduced to a small thickness as will be evident by inspection of Fig. 6, in which a part of the earth and its gaseous envelope is shown to scale. If the radius of the sphere is 12½", then the non-conducting layer is only 1/64" thick and it will be obvious that the Hertzian rays cannot traverse so thin a crack between two conducting surfaces for any considerable distance, without being absorbed. The theory has been seriously advanced that these radiations pass around the globe by *successive reflections,* but to show the absurdity of this suggestion reference is made to Fig. 7 in which this process is diagrammatically indicated. Assuming that there is no refraction, the rays, as shown on the right, would travel along the sides of a polygon drawn around the solid, and inscribed into the conducting gaseous boundary in which case the length of the side would be about 400 miles. As one-half the circumference of the earth is approximately 12,000 miles long there will be, roughly, thirty deviations. The efficiency of such a reflector cannot be more than 25 per cent, so that if none of the energy of the transmitter were lost in other ways, the part recovered would be measured by the fraction $(¼)^{30}$. Let the transmitter radiate Hertz waves at the rate of 1,000 kilowatts. Then about *one hundred and fifteen billionth part of one watt* is all that would be collected in a *perfect* receiver. In truth, the reflections would be much more numerous as shown on the left of the figure, and owing to this and other reasons, on which it is unnecessary to dwell, the amount recovered would be a vanishing quantity.

Consider now the process taking place in the transmission by the instrumentalities and methods of my invention. For this purpose attention is called to Fig. 8, which gives an idea of the mode of propagation of the current waves and is largely self-explanatory. The drawing represents a solar eclipse with the shadow of the moon just touching the surface of the earth at a point where the transmitter is located. As the shadow moves downward it will spread over the earth's surface, first with infinite and then gradually diminishing velocity until at a distance of about 6,000 miles it will attain its true speed in space. From there on it will proceed with increasing velocity, reaching infinite value at the opposite point of the globe. It hardly need be stated that this is merely an illustration and not an accurate representation in the astronomical sense.

The exact law will be readily understood by reference to Fig. 9, in which a transmitting circuit is shown connected to earth and to an antenna. The transmitter being in action, two effects are produced: Hertz waves pass thru the air, and a current traverses the earth. The former propagate with the speed of light and their energy is *unrecoverable* in the circuit. The latter proceeds with the speed varying as the cosecant of the angle which a radius drawn from any point under consideration forms

with the axis of symmetry of the waves. At the origin the speed is infinite but gradually diminishes until a quadrant is traversed, when the velocity is that of light. From there on it again increases, becoming infinite at the antipole. Theoretically the energy of this current is *recoverable* in its entirety, in properly attuned receivers.

Some experts, whom I have credited with better knowledge, have for years contended that my proposals to transmit power without wires are sheer nonsense but I note that they are growing more cautious every day. The latest objection to my system is found in the cheapness of gasoline. These men labor under the impression that the energy flows in all directions and that, therefore, only a minute amount can be recovered in any individual receiver. But this is far from being so. The power is conveyed in only one direction, from the transmitter to the receiver, and none of it is lost elsewhere. It is perfectly practicable to recover at any point of the globe energy enough for driving an airplane, or a pleasure boat or for lighting a dwelling. I am especially sanguine in regard to the lighting of isolated places and believe that a more economical and convenient method can hardly be devised. The future will show whether my foresight is as accurate now as it has proved heretofore.

SHIP RADIO OPERATORS ASK INCREASED WAGES.

Increased wages and the fixing of a standard wage scale for radio operators on vessels operating under Government direction was asked of the Shipping Board recently by a delegation representing the Marconi Radio Telegraphers' Association. The radio operators included in the request made of the Board are those on vessels operating in transatlantic and Gulf waters. Assurances were given the radio representatives by Board officials that their request would be taken under advisement for immediate consideration.

PRESIDENT WILSON ALWAYS IN TOUCH WITH WASHINGTON—VIA RADIO.

(*Continued from page* 708)

Lyons Station, France, was established long before the *Pennsylvania* was beyond communication range of the United States.

The *Pennsylvania* has six receiving booths, which were able to receive on eight different tunes simultaneously as follows: One booth guarded Annapolis or New Brunswick tunes 16,900-13,000 meters; one booth guarded Lyons tunes 15,500 meters; one booth guarded Tuckerton's tune 9,200 meters; one booth guarded 4,000 meters (the Standard arc calling tune); one booth guarded 450 meters for the U. S. S. *George Washington* vacuum tube transmitter tune and one booth guarded 297 meters (the radio telephone tune). One additional operator guarded 600 and 952.

The radio stations at Otter Cliffs, Maine and Lyons, France, were used to receive messages from the President, transmitted by the U. S. S. *Pennsylvania's* arc.

The *George Washington's* radio equipment consisted of the following: One low power spark transmitting set, one 16,900 long wave receiving set, one short wave 600 meter spark receiving set, one short range radio telephone transmitting and receiving set, one vacuum tube 450 meter transmitting and receiving set. The U. S. S. *George Washington* was able to intercept messages transmitted by the Annapolis or New Brunswick stations and guard 600 meter (commercial calling, and emergency tune and the radio telephone and vacuum tunes) simultaneously. Messages for the President transmitted from the United States by the Annapolis, New Brunswick, Tuckerton and the Lyons station were received by the U. S. S. *Pennsylvania* and relayed to the *George Washington* by means of radio telephone and vacuum tube transmitting sets simultaneously.

The messages from the President destined to United States or France were sent from the *George Washington* to the *Pennsylvania* by the vacuum tube or radio telephone set and were relayed by the *Pennsylvania's* high power arc transmitter direct to the United States, Lyons or Brest, France.

The radio communication was directed by Commander H. W. McCormack, U.S.N., Fleet Radio Officer. Lieutenant S. V. Edwards is in charge of the radio of the *Pennsylvania*.

NIKOLA TESLA AND HIS INVENTIONS.

(*Continued from page* 697)

nerve-racking spectacle. Then, inevitably, in the stillness of night, a vivid picture of the scene would thrust itself *before* my eyes and persist despite all my efforts to banish it. Sometimes it would even remain fixt in space tho I pushed my hand thru it. If my explanation is correct, it should be possible to project on a screen the image of any object one conceives and make it visible. Such an advance would revolutionize all human relations. I am convinced that this wonder can and will be accomplished in time to come; I may add that I have devoted much thought to the solution of the problem.

To free myself of these tormenting appearances, I tried to concentrate my mind on something else I had seen, and in this way I would often obtain temporary relief; but in order to get it I had to conjure continuously new images. It was not long before I found that I had exhausted all of those at my command; my "reel" had run out, as it were, because I had seen little of the world—only objects in my home and the immediate surroundings. As I performed these mental operations for the second or third time, in order to chase the

appearances from my vision, the remedy gradually lost all its force. Then I instinctively commenced to make excursions beyond the limits of the small world of which I had knowledge, and I saw new scenes. These were at first very blurred and indistinct, and would flit away when I tried to concentrate my attention upon them, but by and by I succeeded in fixing them; they gained in strength and distinctness and finally assumed the concreteness of real things. I soon discovered that my best comfort was attained if I simply went on in my vision farther and farther, getting new impressions all the time, and so I began to travel—of course, in my mind. Every night (and sometimes during the day), when alone, I would start on my journeys—see new places, cities and countries—live there, meet people and make friendships and acquaintances and, however unbelievable, it is a fact that they were just as dear to me as those in actual life and not a bit less intense in their manifestations.

This I did constantly until I was about seventeen when my thoughts turned seriously to invention. Then I observed to my delight that I could visualize with the greatest facility. I needed no models, drawings or experiments. I could picture them all as real in my mind. Thus I have been led unconsciously to evolve what I consider a new method of materializing inventive concepts and ideas, which is radically opposite to the purely experimental and is in my opinion ever so much more expeditious and efficient. The moment one constructs a device to carry into practise a crude idea he finds himself unavoidably engrost with the details and defects of the apparatus. As he goes on improving and reconstructing, his force of concentration diminishes and he loses sight of the great underlying principle. Results may be obtained but always at the sacrifice of quality.

My method is different. I do not rush into actual work. When I get an idea I start at once building it up in my imagination. I change the construction, make improvements and operate the device in my mind. It is absolutely immaterial to me whether I run my turbine in thought or test it in my shop. *I even note if it is out of balance.* There is no difference whatever, the results are the same. In this way I am able to rapidly develop and perfect a conception without touching anything. When I have gone so far as to embody in the invention every possible improvement I can think of and see no fault anywhere, I put into concrete form this final product of my brain. Invariably my device works as I conceived that it should, and the experiment comes out exactly as I planned it. In twenty years there has not been a single exception. Why should it be otherwise? Engineering, electrical and mechanical, is positive in results. There is scarcely a subject that cannot be mathematically treated and the effects calculated or the results determined beforehand from the available theoretical and practical data. The carrying out into practise of a crude idea as is being generally done is, I hold, nothing but a waste of energy, money and time.

My early affliction had, however, another compensation. The incessant mental exertion developed my powers of observation and enabled me to discover a truth of great importance. I had noted that the appearance of images was always preceded by actual vision of scenes under peculiar and generally very exceptional conditions and I was impelled on each occasion to locate the original impulse. After a while this effort grew to be almost automatic and I gained great facility in connecting cause and effect. Soon I became aware, to my surprise, that every thought I conceived was suggested by an external impression. Not only this but all my actions were prompted in a similar way. In the course of time it became perfectly evident to me that I

was merely an *automaton* endowed with power of movement, responding to the stimuli of the sense organs and thinking and acting accordingly. The practical result of this was the art of *telautomatics* which has been so far carried out only in an imperfect manner. Its latent possibilities will, however, be eventually shown. I have been since years planning self-controlled automata and believe that mechanisms can be produced which will act as if possest of reason, to a limited degree, and will create a revolution in many commercial and industrial departments.

I was about twelve years old when I first succeeded in banishing an image from my vision by wilful effort, but I never had any control over the flashes of light to which I have referred. They were, perhaps, my strangest experience and inexplicable. They usually occurred when I found myself in a dangerous or distressing situation or when I was greatly exhilarated. In some instances I have seen all the air around me filled with tongues of living flame. Their intensity, instead of diminishing, increased with time and seemingly attained a maximum when I was about twenty-five years old. While in Paris, in 1883, a prominent French manufacturer sent me an invitation to a shooting expedition which I accepted. I had been long confined to the factory and the fresh air had a wonderfully invigorating effect on me. On my return to the city that night I felt a positive sensation that my brain had caught fire. I saw a light as tho a small sun was located in it and I past the whole night applying cold compressions to my tortured head. Finally the flashes diminished in frequency and force but it took more than three weeks before they wholly subsided. When a second invitation was extended to me my answer was an emphatic NO!

These luminous phenomena still manifest themselves from time to time, as when a new idea opening up possibilities strikes me, but they are no longer exciting, being of relatively small intensity. When I close my eyes I invariably observe first, a background of very dark and uniform blue, not unlike the sky on a clear but starless night. In a few seconds this field becomes animated with innumerable scintillating flakes of green, arranged in several layers and advancing towards me. Then there appears, to the right, a beautiful pattern of two systems of parallel and closely spaced lines, at right angles to one another, in all sorts of colors with yellow-green and gold predominating. Immediately thereafter the lines grow brighter and the whole is thickly sprinkled with dots of twinkling light. This picture moves slowly across the field of vision and in about ten seconds vanishes to the left, leaving behind a ground of rather unpleasant and inert grey which quickly gives way to a billowy sea of clouds, seemingly trying to mould themselves in living shapes. It is curious that I cannot project a form into this grey until the second phase is reached. Every time, before falling asleep, images of persons or objects flit before my view. When I see them I know that I am about to lose consciousness. If they are absent and refuse to come it means a sleepless night.

To what an extent imagination played a part in my early life I may illustrate by another odd experience. Like most children I was fond of jumping and developed an intense desire to support myself in the air. Occasionally a strong wind richly charged with oxygen blew from the mountains rendering my body as light as cork and then I would leap and float in space for a long time. It was a delightful sensation and my disappointment was keen when later I undeceived myself.

During that period I contracted many strange likes, dislikes and habits, some of which I can trace to external impressions while others are unaccountable. I had a

violent aversion against the earrings of women but other ornaments, as bracelets, pleased me more or less according to design. The sight of a pearl would almost give me a fit but I was fascinated with the glitter of crystals or objects with sharp edges and plane surfaces. I would not touch the hair of other people except, perhaps, at the point of a revolver. I would get a fever by looking at a peach and if a piece of camphor was anywhere in the house it caused me the keenest discomfort. Even now I am not insensible to some of these upsetting impulses. When I drop little squares of paper in a dish filled with liquid, I always sense a peculiar and awful taste in my mouth. I counted the steps in my walks and calculated the cubical contents of soup plates, coffee cups and pieces of food,—otherwise my meal was unenjoyable. All repeated acts or operations I performed had to be divisible by three and if I mist I felt impelled to do it all over again, even if it took hours.

Up to the age of eight years, my character was weak and vacillating. I had neither courage or strength to form a firm resolve. My feelings came in waves and surges and vibrated unceasingly between extremes. My wishes were of consuming force and like the heads of the hydra, they multiplied. I was oppress by thoughts of pain in life and death and religious fear. I was swayed by superstitious belief and lived in constant dread of the spirit of evil, of ghosts and ogres and other unholy monsters of the dark. Then, all at once, there came a tremendous change which altered the course of my whole existence.

Of all things I liked books the best. My father had a large library and whenever I could manage I tried to satisfy my passion for reading. He did not permit it and would fly into a rage when he caught me in the act. He hid the candles when he found that I was reading in secret. He did not want me to spoil my eyes. But I obtained tallow, made the wicking and cast the sticks into tin forms, and every night I would bush the keyhole and the cracks and read, often till dawn, when all others slept and my mother started on her arduous daily task. On one occasion I came across a novel entitled "Abafi" (the Son of Aba), a Serbian translation of a well known Hungarian writer, Josika. This work somehow awakened my dormant powers of will and I began to practise self-control. At first my resolutions faded like snow in April, but in a little while I conquered my weakness and left a pleasure I never knew before—that of doing as I willed. In the course of time this vigorous mental exercise became second nature. At the outset my wishes had to be subdued but gradually desire and will grew to be identical. After years of such discipline I gained so complete a mastery over myself that I toyed with passions which have meant destruction to some of the strongest men. At a certain age I contracted a mania for gambling which greatly worried my parents. To sit down to a game of cards was for me the quintessence of pleasure. My father led an exemplary life and could not excuse the senseless waste of time and money in which I indulged. I had a strong resolve but my philosophy was bad. I would say to him, "I can stop whenever I please but is it worth while to give up that which I would purchase with the joys of Paradise?" On frequent occasions he gave vent to his anger and contempt but my mother was different. She understood the character of men and knew that one's salvation could only be brought about thru his own efforts. One afternoon, I remember, when I had lost all my money and was craving for a game, she came to me with a roll of bills and said, "Go and enjoy yourself. The sooner you lose all we possess the better it will be. I know that you will get over it." She was right. I conquered my passion

then and there and only regretted that it had not been a hundred times as strong. I not only vanquished but tore it from my heart so as not to leave even a trace of desire. Ever since that time I have been as indifferent to any form of gambling as to picking teeth.

During another period I smoked excessively, threatening to ruin my health. Then my will asserted itself and I not only stopt but destroyed all inclination. Long ago I suffered from heart trouble until I discovered that it was due to the innocent cup of coffee I consumed every morning. I discontinued at once, tho I confess it was not an easy task. In this way I checked and bridled other habits and passions and have not only preserved my life but derived an immense amount of satisfaction from what most men would consider privation and sacrifice.

After finishing the studies at the Polytechnic Institute and University I had a complete nervous breakdown and while the malady lasted I observed many phenomena strange and unbelievable.

(To be continued in our March issue)

TEN TELEPHONE OR FORTY TELEGRAPH CURRENTS OVER ONE CIRCUIT.

POSTMASTER GENERAL BURLESON on December 12th made public a letter from Theodore N. Vail announcing the invention and development by the technical staff of the Bell system of a practical method of multiplex telephony and telegraphy, which is expected to revolutionize long-distance wire communication.

Mr. Vail, who is President of the American Telephone and Telegraph Company, explained that there can be a combination of telegraphy and telephony under this invention by which a pair of wires, i.e., one full metallic circuit, will be available either for *five simultaneous telephone conversations (ten voices)* or for *forty simultaneous telegraph messages,* or partly for one and partly for the other.

With this new system four telephone conversations over one pair of wires are simultaneously carried on *in addition to* the telephone conversation provided by the ordinary methods. Thus, over a single pair of wires a total of five telephone conversations are simultaneously operated, each giving service as good as that provided by the circuit working in the ordinary way.

Heretofore the best telephone methods known to the art provided only one telephone conversation at a time over a single pair of wires. A number of years ago there was developed the *phantom circuit* arrangement, by which three telephone circuits were obtained from two pairs of wires, an important improvement, of which extensive use has been made commercially. Now, by the multiplex method we are enabled to obtain *five telephone circuits* over one pair of wires, that is, *ten simultaneous telephone conversations* from the two pairs of wires which formerly could be used for only three simultaneous telephone conversations. This represents an increase of more than threefold in the telephonic capacity of the wires, as compared with the best previous state of the art.

Some proposals made by the earlier workers in this particular field have naturally proved suggestive in the successful solution of the problem, particularly a suggestion made by Maj. Gen. George O. Squier, Chief Signal Officer of the United States Army, about ten years ago, and which at the time attracted very general attention.

Furthermore, while working in entirely different fields and with a different objective, Dr. Lee deForest a number of years ago invented a wireless device known as the Audion, which by improvements and adaptation has been made an important part of the Bell telephone system.

MARCH, 1919
20 CTS.

ELECTRICAL EXPERIMENTER

SCIENCE AND INVENTION

OVER 175 ILLUST.

SEARCH LIGHTS OF THE DEEP

SEE PAGE 772

Electrical Experimenter

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Vol. VI. Whole No. 71 MARCH, 1919 No. 11

EDITORIAL

Underground Wireless

ELSEWHERE in this issue is disclosed in full detail for the first time what U. S. Navy officials term as the greatest American War Invention: "Underground and Sub-sea Wireless."

Last month we hinted editorially on the theoretical aspect of the problem—this month we are face to face with the accomplisht fact. The war has revolutionized not only peoples, nations and the whole world, but many hitherto unshakable scientific institutions as well. For over twenty years the wireless aërial—the elevated aërial wire system—was synonymous with the wireless art. The great radio station, the transatlantic liner, could not well be imagined without its ubiquitous stretch of elevated wires. The greatest pride of the radio amateur, the aërial on top of his house, which to him was symbolic of the young art, is doomed. This change has been brought about over night by the magic wand of science and her servant—Mr. James Harris Rogers, American, of Hyattsville, Md.

The aërial wires, down for the duration of the war, will never go up, at least as far as amateurs and private stations are concerned. As for the commercial stations, their towers too are doomed shortly for the scrap-heap. During the war Mr. Rogers developed underground and sub-sea wireless—for receiving at least—to a heretofore undreamt of state of perfection. His receiving station at Hyattsville never mist a word transmitted from French, English, Italian as well as German high power stations. *He received his messages from Europe when a thunderstorm, accompanied by terrific lightning, was going on directly above his head.* Recently, too, *he has done away entirely with static.*

When the big station at Arlington, near Washington, was out of touch with Europe, due to static disturbances, Mr. Rogers went right on receiving over his buried underground wires, just as if static never existed. Indeed the Rogers invention knows no static. Static being an atmospheric condition, a ground antenna naturally will not be affected by it.

But the most spectacular feature of Mr. Rogers' revolutionizing invention probably is his "Sub-sea Wireless." Scientists the world over, Marconi included, declared it an utter impossibility to communicate by wireless with a totally submerged submarine. Mr. Rogers, however, goes right ahead and does it, not only in fresh water *but thru salt water as well.* Indeed he establisht wireless communication with a submarine *whose aërial wires were 25 feet below the surface of the ocean!*

Altho Mr. Rogers, during the war, gave most of his attention toward receiving messages, he has made considerable progress in underground radio transmission as well. His experiments prove conclusively that, while underground radio receiving is here to stay, underground sending too will soon be practical enough, even for high power stations. It is merely a question of good insulation at present, and the end of this year, we are quite confident, will bring the solution of the problem. The Navy Department has just succeeded in transmitting a distance of 50 miles with the underground system.

At first it would seem reasonable that only long wave lengths could be used with the Rogers system. But this is not the case. Underground Radio-telephone messages, seven miles distant, come in just as clear on 300 meters wave length as does the Nauen (Germany) station with 12,600 meters wave length. This indeed is good news for our amateurs.

But in the meanwhile, all of our pet theories on wireless are thrown in a sad chaos. For we do not know as yet how the Rogers system works. We can now expect a war to the knife between our wave-propagation theorists and the new school of ground-impulse savants. Mr. Rogers himself takes the view—and he is seconded by Tesla—that the transoceanic messages which he receives over his underground system *are not Hertzian waves*—pure or even converted—but merely high frequency ground impulses.

The future may tell us which school is right.

H. GERNSBACK.

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Tesla's Egg of Columbus

How Tesla Performed the Feat of Columbus Without Cracking the Egg

PROBABLY one of the most far-reaching and revolutionary discoveries made by Mr. Tesla is the so-called *rotating magnetic field.* This is a new and wonderful manifestation of force —a magnetic cyclone—producing striking with any speed desired. Long ago, when Tesla was still a student, he conceived the idea of the rotating magnetic field and this remarkable principle is embodied in his famous *induction motor* and system of transmission of power now in universal use.

In this issue of the ELECTRICAL EXPERIMENTER Mr. Tesla gives a remarkable account of his early efforts and trials as an inventor and of his final success. Unlike other technical advances arrived at thru the usual hit and miss methods and hap-

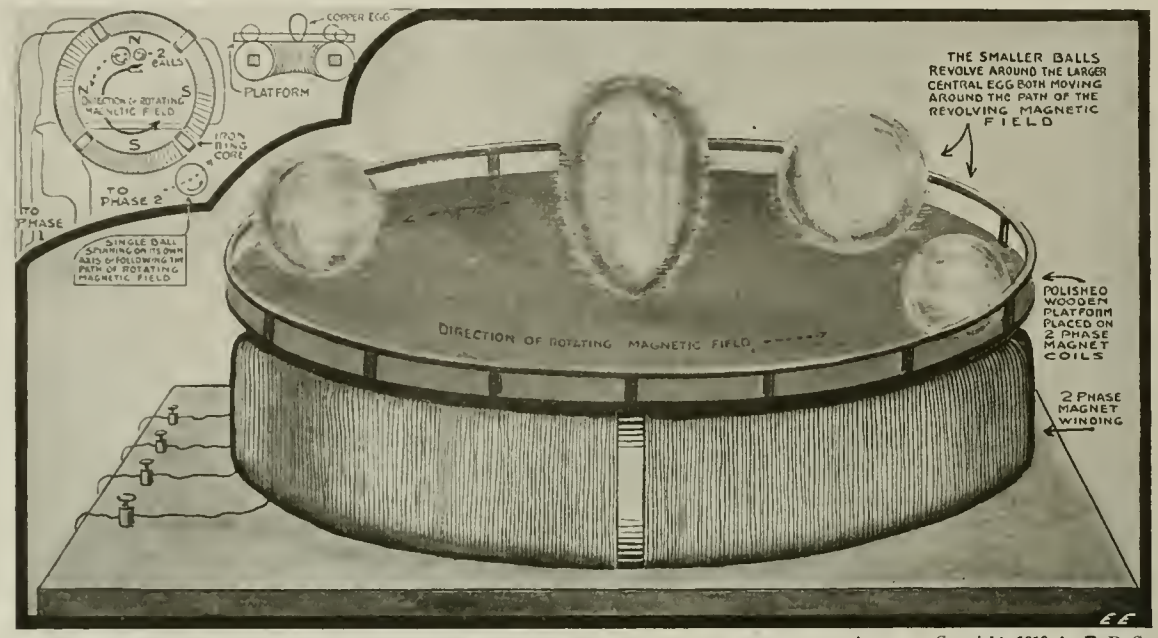

Fig. 2. Illustrating the Polyphase Coil and Rotating Megnetic Field Which Caused Copper Eggs to Spin. Fig. 3. Insert: Detail of Coil Apparatus Showing Coil Connections to Different Phases.

phenomena which amazed the world when they were first shown by him. It results from the joint action of two or more alternating currents definitely related to one another and creating magnetic fluxes, which, by their periodic rise and fall according to a mathematical law, cause a continuous shifting of the lines of force. There is a vast difference between an ordinary electro-magnet and that invented by Tesla. In the former the lines are stationary, in the latter they are made to whirl around at a furious rate. The first attracts a piece of iron and holds it fast; the second causes it to spin in any direction and

Fig. 1. This hitherto unpublisht photograph is extremely interesting as it shows not only "Tesla's Electric Egg" apparatus in the center of the background, but also a comprehensive view of a corner of his famous Houston Street laboratory of a decade ago. At the left may be seen a number of Tesla's oscillators or high frequency generators, while in the rear may be noted a large high frequency transformer of the spiral type, the diameter of which was a little over nine feet. The electric egg apparatus comprising a two-phase A.C. circular core and winding, rests on a table, and this particular model measured about two feet across. In making the demonstrations, Tesla applied as much as 200 H.P. from a two-phase alternator to the exciting coils, and so intense was the revolving magnetic field created in the surrounding space, that small delicately pivoted iron discs would revolve in any part of the hall, and a great many other devices could be simultaneously operated from this magnetic field when thus excited. The frequency of the two-phase A.C. energizing the coils, was varied from 25 to 300 cycles, the best results being obtained with currents of from 35 to 40 cycles. This laboratory was lighted by Tesla's vacuum tubes, several of which may be seen on the ceiling, and each of which emitted 50 C.P. The coil resting on three legs and observed in the immediate foreground is the primary of a resonant Tesla transformer which collected energy from an oscillatory circuit encircling the laboratory, no matter in what position the transformer was placed. A low tension secondary of one or two turns of heavy cable (not visible) was provided for stepping down the energy collected by "mutual induction," and supplied the current to incandescent lamps, vacuum tubes, motors and other devices. When the circuit around the hall was strongly excited, the secondary furnished energy at the rate of about three-quarters of one horse-power.

hazard experimentation, the rotating field was purely the work of scientific imagination. Tesla developed and perfected, entirely in his mind, this great idea in all its details and applications *without making one single experiment.* Not even the usual first model was used. When the various forms of apparatus he had devised were tried for the first time they worked exactly as he had imagined and he took out some forty fundamental patents covering the whole vast region he had explored. He obtained the first rotations in the summer of 1883 after five years of constant and intense thought on the subject and then undertook

the equally difficult task of finding believers in his discovery. The alternating current was but imperfectly understood and had no standing with engineers or electricians and for a long time Tesla talked to deaf ears. But, ultimately, his pains were rewarded and early in 1887 a company bearing his name was formed for the commercial introduction of the invention.

Dr. Tesla recently told the editors an amusing incident in this connection. He had approached a Wall Street capitalist—a prominent lawyer—with a view of getting financial support and this gentleman called in a friend of his, a well-known engineer at the head of one of the big corporations in New York, to pass upon the merits of the scheme. This man was a practical expert who knew of the failures in the industrial exploitation of alternating currents and was distinctly prejudiced to a point of not caring even to witness some tests. After several discouraging conferences Mr. Tesla had an inspiration. Everybody has heard of the "Egg of Columbus." The saying goes that at a certain dinner the great explorer asked some scoffers of his project to balance an egg on its end. They tried it in vain. He then took it and cracking the shell slightly by a gentle blow, made it stand upright. This may be a myth but the fact is that he was granted an audience by Isabella, the Queen of Spain, and won her support. There is a suspicion that she was more imprest by his portly bearing than the prospect of his discovery. Whatever it might have been, the Queen pawned her jewels and three ships were equipt for him and so it happened that the Germans got all that was coming to them in this war. But to return to Tesla's reminiscence. He said to these men, "Do you know the story of the Egg of Columbus?" Of course they did. "Well," he continued, "what if I could make an egg stand on the pointed end without cracking the shell?" "If you could do this we would admit that you had gone Columbus one better." "And would you be willing to go out of your way as much as Isabella?" "We have no crown jewels to pawn," said the lawyer, who was a wit, "but there are a few ducats in our buckskins and we might help you to an extent."

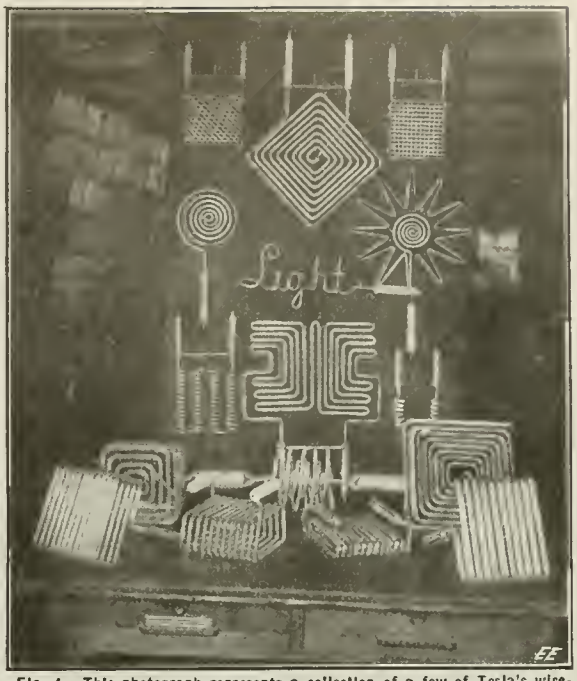

Fig. 4. This photograph represents a collection of a few of Tesla's wireless lamps, such as he proposes to use in lighting isolated dwellings all over the world from central wireless plants. The two lamps at either corner at the bottom are illuminated, owing to the fact that a high frequency oscillator was in operation some distance away when this photograph was being taken. These tubes were filled with various gases for experimental research work in determining which was most efficient.

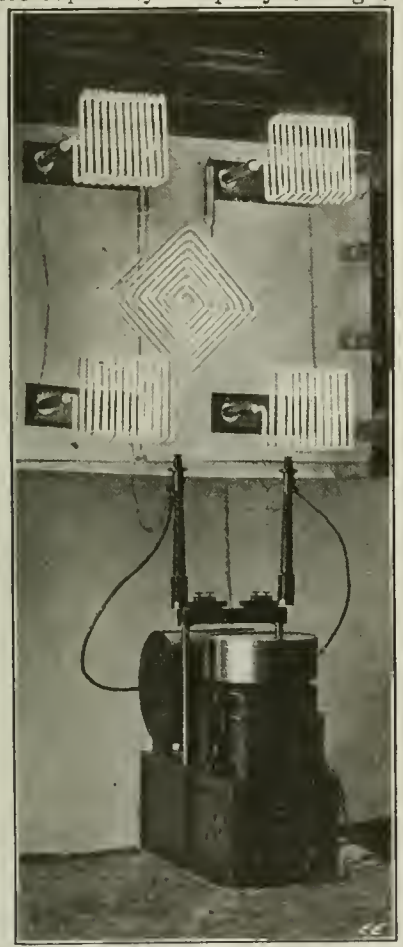

Fig. 5. This illustration shows one of Tesla's high frequency oscillation generators and a bank of his high frequency lamps lighted by the same. These highly evacuated, gas filled tubes were operated in different ways. In some cases they were connected to one wire only; in other instances to two wires, in the manner of ordinary incandescent lamps. Often, however, they were operated without any connection to wires at all, i.e., by "wireless energy". over quite appreciable distances, which could have been greatly extended with more power. The oscillator comprises a Tesla high potential transformer which is excited from a condenser and circuit controller, as described in his patents of 1896. The primary exciting element comprised a powerful electro-magnet actuating an armature, and this circuit was connected with 110 volt, 60 cycle A.C. or D.C. When the oscillator was put into operation, the interrupter actuated by the electro-magnet connected to the 110 volt circuit, became simultaneously the spark gap for the high potential exciting circuit, which included this vibrator, spark gap, a high tension condenser and the primary of the high frequency Tesla transformer. The lamps were connected to the secondary of the latter the terminals of which are seen in the rear of the machine.

Mr. Tesla thus succeeded in capturing the attention and personal interest of these very busy men, extremely conservative and reluctant to go into any new enterprise, and the rest was easy. He arranged for a demonstration the following day. A rotating field magnet was fastened under the top board of a wooden table and Mr. Tesla provided a copper-plated egg and several brass balls and pivoted iron discs for convincing his prospective associates. He placed the egg on the table and, to their astonishment, it stood on end, but when they found that it was *rapidly spinning* their stupefaction was complete. The brass balls and pivoted iron discs in turn were set spinning rapidly by the rotating field, to the amazement of the spectators. No sooner had they regained their composure than Tesla was delighted with the question: "Do you want any money?" "Columbus was never in a worse predicament," said the great inventor, who had parted with his last portrait of George Washington in defraying the expenses of the preparation. Before the meeting adjourned he had a substantial check in his pocket, and it was given with the assurance that there was more to be had in the same bank. That started the ball rolling. Tens of millions of horsepower of Tesla's induction motors are now in use all over the world and their production is rising like a flood.

In 1893 Mr. Albert Schmid, then Superintendent of the Westinghouse Electric and Mfg. Co. constructed a powerful rotating field ring with an egg made of copper, and larger than that of an ostrich, for Dr. Tesla's personal collection at the Chicago World's Fair. This piece of apparatus was one of the most attractive novelties ever publicly shown and drew enormous crowds every day. Subsequently it was taken to Mr. Tesla's laboratory and served there permanently for demonstrating rotating field phenomena. In his experiments it was practicable to use as much as 200 *horsepower* for a short time, without overheating the wires and the effects of the magnetic forces were wonderfully fascinating to observe. This is the very ring indicated in the accompanying photograph (Fig. 1), giving a view of Mr. Tesla's former laboratory at 46 E. Houston Street, New York. It is shown in detail in Fig. 2, and the mode of winding is illustrated in diagram (Fig. 3). Originally the two-phase arrangement was provided but Mr. Tesla transformed it to the three- and four-phase when desired. On top of the ring was fastened a thin circular board, slightly hollowed, and provided around its circumference with a guard to prevent the objects from flying off.

Even more interesting than the spinning egg was the exhibition of *planetary motion*. In this experiment one large, and several small brass balls were usually employed. When the field was energized all the balls would be set spinning, the large one remaining in the center while the small ones revolved around it, like moons about a planet, gradually receding until they reached the outer guard and raced along the same.

But the demonstration which most imprest the audiences was the simultaneous operation of numerous balls, pivoted discs and other devices placed in all sorts of positions and *at considerable distances from the rotating field*. When the currents were turned on and the whole animated with motion, it presented an unforgettable spectacle. Mr. Tesla had many vacuum bulbs in which small, light metal discs were pivotally arranged on jewels and these would spin anywhere in the hall when the iron ring was energized.

Rotating fields of 15,000 horsepower are now being turned out by the leading manufacturers and it is very likely that in the near future capacities of 50,000 horsepower will be employed in the steel and other industries and ship propulsion by Tesla's electric drive which, according to Secretary of the Navy Daniels' statement, has proved a great success.

But any student interested in these phenomena can repeat all the classical experiments of Tesla by inexpensive apparatus. For this purpose it is only necessary to make two slip ring connections on an ordinary small direct current motor or dynamo and to wind an iron ring with four coils as indicated in diagram Fig. 3. No particular rule need be given for the windings but it may be stated that he will get the best results if he will use an iron ring of comparatively *small section* and wind it *with as many turns of stout wire as practicable*. He can heavily copper plate an egg but he should bear in mind that Tesla's egg is not as innocent as that of Columbus. The worst that can happen with the latter is that it might be,—er—over ripe! but the Tesla egg may explode with disastrous effect because the copper plating is apt to be brought to a high temperature thru the induced currents. The sensible experimenter will, therefore, first suck out the contents of the egg—thus satisfying both his appetite and thirst for knowledge.

Besides the rotating field apparatus Mr.

(*Continued on page* 808)

My Inventions

By Nikola Tesla

2. MY FIRST EFFORTS IN INVENTION

I SHALL dwell briefly on these extraordinary experiences, on account of their possible interest to students of psychology and physiology and also because this period of agony was of the greatest consequence on my mental development and subsequent labors. But it is indispensable to first relate the circumstances and conditions which preceded them and in which might be found their partial explanation.

BOYS will be boys, the world over. The Boy Tesla was no exception to the universal rule, as this, his second autobiographical article clearly proves.

Mr. Tesla in his own inimitable, delightful way, here paints with a literary artist's brush his own intimate boyhood in charming as well as vivid colors.

We have often heard of Tesla, the dreamer. But if he is entitled to the epithet, his early boyhood certainly fails to reveal it. Tesla did not allow much grass to grow under his feet while a boy, for he assuredly was a strenuous, red-blooded youngster.

You will wish to read all about the greatest inventor's early boyhood. It is doubly valuable because it comes from his own pen. We promise you an interesting twenty-minutes' entertainment.

—EDITOR.

From childhood I was compelled to concentrate attention upon myself. This caused me much suffering but, to my present view, it was a blessing in disguise for it has taught me to appreciate the inestimable value of introspection in the preservation of life, as well as a means of achievement. The pressure of occupation and the incessant stream of impressions pouring into our consciousness thru all the gateways of knowledge make modern existence hazardous in many ways. Most persons are so absorbed in the contemplation of the outside world that they are wholly oblivious to what is passing on within themselves. The premature death of millions is primarily traceable to this cause. Even among those who exercise care it is a common mistake to avoid imaginary, and ignore the real dangers. And what is true of an individual also applies, more or less, to a people as a whole. Witness, in illustration, the prohibition movement. A drastic, if not unconstitutional, measure is now being put thru in this country to prevent the consumption of alcohol and yet it is a positive fact that coffee, tea, tobacco, chewing gum and other stimulants, which are freely indulged in even at the tender age, are vastly more injurious to the national body, judging from the number of those who succumb. So, for instance, during my student years I gathered from the published necrologues in Vienna, the home of coffee drinkers, that deaths from heart trouble sometimes reached *sixty-seven per cent* of the total. Similar observations might probably be made in cities where the consumption of tea is excessive. These delicious beverages superexcite and gradually exhaust the fine fibers of the brain. They also interefere seriously with arterial circulation and should be enjoyed all the more sparingly as their deleterious effects are slow and imperceptible. Tobacco, on the other hand, is conducive to easy and pleasant thinking and detracts from the intensity and concentration necessary to all original and vigorous effort of the intellect. Chewing gum is helpful for a short while but soon drains the glandular system and inficts irreparable damage, not to speak of the revulsion it creates. Alcohol in small quantities is an excellent tonic, but is toxic in its action when absorbed in larger amounts, quite immaterial as to whether it is taken in as whiskey or produced in the stomach from sugar. But it should not be overlooked that all these are great eliminators assisting Nature, as they do, in upholding her stern but just law of the survival of the fittest. Eager reformers should also be mindful of the eternal perversity of mankind which makes the indifferent *"laissez-faire"* by far preferable to enforced restraint. The truth about this is that we need stimulants to do our best work under present living conditions, and that we must exercise moderation and control our appetites and inclinations in every direction. That is what I have been doing for many years, in this way maintaining myself young in body and mind. Abstinence was not always to my liking but I find ample reward in the agreeable experiences I am now making. Just in the hope of converting some to my precepts and convictions I will recall one or two.

This Photograph Shows in the Background the House in Which Mr. Tesla's Family Resided. The Edifice at the Right Is the "Real Gymnasium" Where He Studied. The Ecclesiastic Gentleman Is His Uncle, the Metropolitan of Bosnia, Who Was a Great Statesman and Who Thwarted the Designs of Austria Upon Serbia at a Critical Period.

A short time ago I was returning to my hotel. It was a bitter cold night, the ground slippery, and no taxi to be had. Half a block behind me followed another man, evidently as anxious as myself to get under

(*Cont. on page* 839)

An interesting study of the great inventor, contemplating the glass bulb of his famous wireless light. A full description of the invention will appear shortly in the ELECTRICAL EXPERIMENTER. *This is the only profile photograph of Mr. Tesla in existence. It was taken specially for the* ELECTRICAL EXPERIMENTER.

EXPERIMENTAL PHYSICS.

(*Continued from page 806*)

near the electroscope, we find that the electroscope discharges rapidly. The Bunsen flame ionizes the air very rapidly. A small quantity of radio-active material will discharge the electroscope very rapidly, showing that *radio-active materials have the ability to IONIZE the air.* The larger the amount of radio-active material the faster the rate of discharge of the electroscope. A pinch of Uranium Oxid in the electroscope chamber, will ionize the air so rapidly that the leaf will fall practically instantaneously!

Experiment 113.

A third test for the presence of most radio-active substances is the "*Fluorescence Effect*"—which some of them have upon certain compounds, especially *Zinc Sulfid.* Any of the substances which give off alpha radiations (see figure 102) will cause a zinc sulfid screen to fluoresce. If the screen is observed thru a sufficiently high power magnifying lens, or microscope (say ten or fifteen diameters magnification), the continuous soft glow of the zinc sulfid seen by the naked eye becomes, on magnification, hundreds of tiny flashes of light, not unlike the sparks obtained by striking flint and steel together. Figure 101 shows the *Spinthariscope*, which can be easily made by the reader. A is small metal tube with a hole, S, in its cap. E and F are lenses. C is the fluorescent screen on the cap of tube B. D is a small particle of the radio-active substance. A practical use of the fluorescent effect of alpha particles is familiar to all of us in the *radium paints, luminous dials*, et cetera. These compounds consist of specially prepared zinc sulfid, mixed with about 2,000 parts of radium bromid, or a radio-active compound having an equivalent of alpha-ray activity. Altho the period of half decay of radium itself is approximately 2,000 years, see table 102, the luminosity of the compound falls off, due to the fact that the *zinc sulfid loses its power to luminesce*, but not because the radium gives out. Some specifications for luminous paint, as for government work, stipulate that the zinc sulfid and radio-active substance shall be mixed in such proportions that the average useful life of the paint will be from 8 to 10 years.

The discovery of radio-activity has given us a vast field for research and as a result the physicist has been able to make subatomic investigations. Atoms are constantly exploding and shoot out as fragments, the alpha and beta particles. Altho the energy liberated by these explosions is fairly large, no diminution in the weight of the radio-active substance has been detected after the liberation of the energy. J. J. Thomson computed that the disintegration of one gram of hydrogen would liberate sufficient energy to raise a million tons 300 feet. See Fig. 103. If only this energy could be trapt, and recent research shows the possibility of it, Garfield and his coal-house gang would lose their job, for who would use ten tons of coal when one gram of hydrogen would give an equivalent heating value. Table 102 gives interesting data concerning the radio-active substances. In each series the first substance gives the second on disintegration and the second the third, etc. The second column gives the kind of radiation given off by the respective substances and the last column tells how long it takes for the substance to disintegrate to half of the original amount. This half-period means that after 2,000 years, for instance, one-half of the substance in question will have disintegrated. After 4,000 years, one-half of the remainder will have disintegrated or disappeared, etc., etc. The total life of pure Radium is computed from this law to be about 22,000 years.

(*To be continued*)

HISTORIC ELECTRIC SWITCHBOARD AND DYNAMO.

(*Continued from page 778*)

field magnet type with surface wound armatures. There are quite a number of these generators still in existence in various parts of the country, and in tribute to their designer, it should be said that they perform their duty very well indeed, considering the time at which they were built, for thirty to thirty-five years in the electrical industry has, we might almost say, witnest the entire development of the whole scheme of electrical generation, transmission and utilization of power, under the directorship of such men as Edison, Thomson, Houston. Tesla, Westinghouse and Sprague.

The wooden switch-board, shown in the photograph, contains four box-type field rheostats, and it is peculiar to note that they are mounted on the face of the board instead of in the rear, as in present day practise.—*Photo by Richard Nelson.*

THE TESLA EGG OF COLUMBUS.

(*Continued from page 775*)

Tesla had other surprises for his audiences. which were even more wonderful. So, for instance, the coil on three legs, visible in the foreground, was used to operate wireless motors, lamps and other devices, and the spiral coil in the background served to show extraordinary high potential phenomena, as streamers of great length.

ULTRAVIOLET ENERGY AND ITS USE.

By M. Luckiesh, Physicist, Nela Research Laboratory.

Since the discovery of ultraviolet rays, more than a century ago, their production and properties have been subjected to a great deal of investigation. However, notwithstanding the extensive literature on the subject we must agree with Sheppard, who says in his book on Photo-chemistry:

"We are only at the beginning of the conscious utilization of the powers of light, as distinct from the unconscious enjoyment of them."

Owing to the many unique properties of these invisible rays, they are extremely valuable in certain scientific investigations, tests, and industrial processes, and it appears certain, that with the progress of the development of sources of ultraviolet rays, and of media transparent to them, the usefulness of ultraviolet energy will be rapidly extended. The problems in which these unique properties may be utilized are manifold.

As to Sources:—There are many sources of ultraviolet energy, but few are powerful enough to be widely useful. The ideal source, which emits a continuous nonbanded spectrum of high intensity thruout the entire ultraviolet region, does not exist. Some of the sources are here ranked in order: magnetite arc, old mercury arc, new mercury arc, and carbon arc.

The blue flame arc emits ultraviolet energy very strongly. It is a simple matter to construct an arc which will emit ultraviolet energy strongly, provided hand-control is satisfactory. An iron rod and a carbon rod may be employed successfully for the two poles, however two iron rods may answer the purpose very well. These poles may be kept cool effectively by means of heavy brass or copper sleeves, which may be wound along the iron rods as the latter are consumed.

Uses of Ultraviolet Rays:—Ionization of air; powerful bactericidal agent; kill germs in water; effect upon animal tissue to bronze the skin. In industrial processes such as acetylene and arc welding, which are attended by powerful ultraviolet energy, there is a demand for eye-protecting glasses.

THE ROGERS UNDERGROUND WIRELESS.

(*Continued from page* 835)

thusa" at sea about 150 miles from New Orleans.

Main Antenna		Underground Antenna (500' composite)	
Sig	Static	Sig.	Static
400	5000	300	15

The "Arethusa" had been trying to get thru a naval despatch which could not be copied on elevated antenna on account of serious static interference. The despatch was taken on the underground antenna, and *every word copied correctly.*

At 9 P. M., April 7, 1917, it was possible to copy signals from Tuckerton with ease, while static on the elevated antenna made it impossible to read any arc signals.

The following results were obtained with spark signals:

Three hundred foot wires in parallel, ten feet apart, a .002 m.f. condenser in series with primary coil of a Telefunken receiver to obtain 600 meters.

Date	Station	W. L.	Sig. Aud Ground Antenna	Static Aud Ground Antenna	Sig Aud Main Antenna	Static Aud Main Antenna
Apr. 2	Point Isabel	600	15			
Apr. 2	Tampa	600	200	0		3000
Apr. 2	Port Arthur	600	150	0		3000
Apr. 2	Pensacola	1200	20	0	100	150
Apr. 2	Ft. Sam Houston		150			

Of particular interest is the fact that when static *prevents* reception on the main antenna, reception can be continued on the underground antenna. *This has even been done during a severe lightning storm, when the main antenna would have been dangerous without grounding.* Reception is also directional and permits of avoiding interference to some extent by using wire "off direction" of an interfering station.

Strays: Strays are as a rule practically absent. Occasional loud cracks widely separated are received. (Ed. note. This has since been overcome.) These isolated strays, altho frequently loud, do not interfere in the least with the reception of signals. On two occasions, strays have risen to an audibility in excess of 5,000 on these separate cracks, but even in this case, reception of signals, altho a little difficult, *was not interrupted.* On these two occasions it was necessary to *ground* both of the (elevated) aërials at the main station.

Considering the matter of strays, it can be said that on four or five occasions during one week, which was one marked by tremendous storms in the Great Lakes region, that strays rose to an audibility in excess of 10,000 at the beach station. Even in this case, however, signals from boats within 100 miles and from shore stations, such as Ludington, Milwaukee and Manitowoc, were usually readable, because the strays while very loud, were nowhere near as numerous as on the elevated aërial. Durthese periods a messenger was kept at the beach station to carry up messages to the main station, which could not receive these signals on account of the strays.

There seems to be no appreciable advantage in using more than one wire—No. 12 weather proof insulated.

The experiments at Great Lakes confirm the work of the Bureau of Standards on the importance of adequate insulation of the wire. If the wires are grounded at the ends, it does not necessarily make much difference unless they are adjusted to the optimum wire length; but if properly adjusted to this length, grounding of the wires, either intentionally or accidentally, produces a diminuation of the signals, which, however, even with the intentional grounding of the two ends, still leaves them 50% of their maximum value. Therefore, while the question of insulation is important, it does not mean that the system will fail entirely if the insulation becomes faulty.

MY INVENTIONS.

(*Continued from page* 776)

cover. Suddenly my legs went up in the air. In the same instant there was a flash in my brain, the nerves responded, the muscles contracted, I swung thru 180 degrees and landed on my hands. I resumed my walk as tho nothing had happened when the stranger caught up with me. "How old are you?" he asked, surveying me critically. "Oh, about fifty-nine," I replied. "What of it?" "Well," said he, "I have seen a cat do this but never a man." About a month since I wanted to order new eyeglasses and went to an oculist who put me thru the usual tests. He lookt at me incredulously as I read off with ease the smallest print at considerable distance. But when I told him that I was past sixty he gasped in astonishment. Friends of mine often remark that my suits fit me like gloves but they do not know that all my clothing is made to measurements which were taken nearly 35 years ago and never changed. During this same period my weight has not varied one pound.

In this connection I may tell a funny story. One evening, in the winter of 1885, Mr. Edison, Edward H. Johnson, the President of the Edison Illuminating Company, Mr. Batchellor, Manager of the works, and myself entered a little place opposite 65 Fifth Avenue where the offices of the company were located. Someone suggested guessing weights and I was induced to step on a scale. Edison felt me all over and said: "Tesla weighs 152 lbs. to an ounce," and he guest it exactly. Stript I weighed 142 lbs. and that is still my weight. I whispered to Mr. Johnson: "How is it possible that Edison could guess my weight so closely?" "Well," he said, lowering his voice, "I will tell you, confidentially, but you must not say anything. He was employed for a long time in a Chicago slaughter-house where he weighed thousands of hogs every day! That's why." My friend, the Hon. Chauncey M. Depew, tells of an Englishman on whom he sprung one of his original anecdotes and who listened with a puzzled expression but—a year later—laughed out loud. I will frankly confess it took me longer than that to appreciate Johnson's joke.

Now, my well being is simply the result of a careful and measured mode of living and perhaps the most astonishing thing is that three times in my youth I was rendered by illness a hopeless physical wreck and given up by physicians. More than this, thru ignorance and lightheartedness, I got into all sorts of difficulties, dangers and scrapes from which I extricated myself as by enchantment. I was almost drowned a dozen times; was nearly boiled alive and just mist being cremated. I was entombed, lost and frozen. I had hair-breadth escapes from mad dogs, hogs, and other wild animals. I past thru dreadful diseases and met with all kinds of odd mishaps and that I am hale and hearty today seems like a miracle. But as I recall these incidents to my mind I feel convinced that my preservation was not altogether accidental.

An inventor's endeavor is essentially life-saving. Whether he harnesses forces, improves devices, or provides new comforts and conveniences, he is adding to the safety of our existence. He is also better qualified than the average individual to protect himself in peril, for he is observant and resourceful. If I had no other evidence that I was, in a measure, possest of such qualities I would find it in these personal experiences. The reader will be able to judge for himself if I mention one or two instances. On one occasion, when about 14 years old, I wanted to scare some friends who were bathing with me. My plan was to dive under a long floating structure and slip out quietly at the other end. Swimming and diving came to me as naturally as to a

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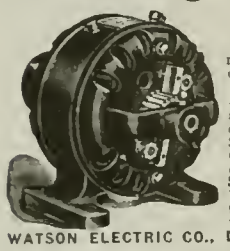

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duck and I was confident that I could perform the feat. Accordingly I plunged into the water and, when out of view, turned around and proceeded rapidly towards the opposite side. Thinking that I was safely beyond the structure, I rose to the surface but to my dismay struck a beam. Of course, I quickly dived and forged ahead with rapid strokes until my breath was beginning to give out. Rising for the second time, my head came again in contact with a beam. Now I was becoming desperate. However, summoning all my energy, I made a third frantic attempt but the result was the same. The torture of suppressed breathing was getting unendurable, my brain was reeling and I felt myself sinking. At that moment, when my situation seemed absolutely hopeless, I experienced one of those flashes of light and the structure above me appeared before my vision. I either discerned or guest that there was a little space between the surface of the water and the boards resting on the beams and, with consciousness nearly gone, I floated up, prest my mouth close to the planks and managed to inhale a little air, unfortunately mingled with a spray of water which nearly choked me. Several times I repeated this procedure as in a dream until my heart, which was racing at a terrible rate, quieted down and I gained composure. After that I made a number of unsuccessful dives, having completely lost the sense of direction, but finally succeeded in getting out of the trap when my friends had already given me up and were fishing for my body.

That bathing season was spoiled for me thru recklessness but I soon forgot the lesson and only two years later I fell into a worse predicament. There was a large flour mill with a dam across the river near the city where I was studying at that time. As a rule the height of the water was only two or three inches above the dam and to swim out to it was a sport not very dangerous in which I often indulged. One day I went alone to the river to enjoy myself as usual. When I was a short distance from the masonry, however, I was horrified to observe that the water had risen and was carrying me along swiftly. I tried to get away but it was too late. Luckily, tho, I saved myself from being swept over by taking hold of the wall with both hands. The pressure against my chest was great and I was barely able to keep my head above the surface. Not a soul was in sight and my voice was lost in the roar of the fall. Slowly and gradually I became exhausted and unable to withstand the strain longer. Just as I was about to let go, to be dashed against the rocks below, I saw in a flash of light a familiar diagram illustrating the hydraulic principle that the pressure of a fluid in motion is proportionate to the area exposed, and automatically I turned on my left side. As if by magic the pressure was reduced and I found it comparatively easy in that position to resist the force of the stream. But the danger still confronted me. I knew that sooner or later I would be carried down, as it was not possible for any help to reach me in time, even if I attracted attention. I am ambidextrous now but then I was left-handed and had comparatively little strength in my right arm. For this reason I did not dare to turn on the other side to rest and nothing remained but to slowly push my body along the dam. I had to get away from the mill towards which my face was turned as the current there was much swifter and deeper. It was a long and painful ordeal and I came near to failing at its very end for I was confronted with a depression in the masonry. I managed to get over with the last ounce of my force and fell in a swoon when I reached the bank, where I was found. I had torn virtually all the skin from my left side and it took several weeks before the fever subsided and I was well. These are only two

of many instances but they may be sufficient to show that had it not been for the inventor's instinct I would not have lived to tell this tale.

Interested people have often asked me how and when I began to invent. This I can only answer from my present recollection in the light of which the first attempt I recall was rather ambitious for it involved the invention of an *apparatus* and a *method*. In the former I was anticipated but the latter was original. It happened in this way. One of my playmates had come into the possession of a hook and fishing-tackle which created quite an excitement in the village, and the next morning all started out to catch frogs. I was left alone and deserted owing to a quarrel with this boy. I had never seen a real hook and pictured it as something wonderful, endowed with peculiar qualities, and was despairing not to be one of the party. Urged by necessity, I somehow got hold of a piece of soft iron wire, hammered the end to a sharp point between two stones, bent it into shape, and fastened it to a strong string. I then cut a rod, gathered some bait, and went down to the brook where there were frogs in abundance. But I could not catch any and was almost discouraged when it occurred to me to dangle the empty hook in front of a frog sitting on a stump. At first he collapsed but by and by his eyes bulged out and became bloodshot, he swelled to twice his normal size and made a vicious snap at the hook. Immediately I pulled him up. I tried the same thing again and again and the method proved infallible. When my comrades, who in spite of their fine outfit had caught nothing, came to me they were green with envy. For a long time I kept my secret and enjoyed the monopoly but finally yielded to the spirit of Christmas. Every boy could then do the same and the following summer brought disaster to the frogs.

In my next attempt I seem to have acted under the first instinctive impulse which later dominated me—to harness the energies of nature to the service of man. I did this thru the medium of May-bugs—or June-bugs as they are called in America—which were a veritable pest in that country and sometimes broke the branches of trees by the sheer weight of their bodies. The bushes were black with them. I would attach as many as four of them to a cross-piece, rotably arranged on a thin spindle, and transmit the motion of the same to a large disc and so derive considerable "power." These creatures were remarkably efficient, for once they were started they had no sense to stop and continued whirling for hours and hours and the hotter it was the harder they worked. All went well until a strange boy came to the place. He was the son of a retired officer in the Austrian Army. That urchin ate May-bugs alive and enjoyed them as tho they were the finest blue-point oysters. That disgusting sight terminated my endeavors in this promising field and I have never since been able to touch a May-bug or any other insect for that matter.

After that, I believe, I undertook to take apart and assemble the clocks of my grandfather. In the former operation I was always successful but often failed in the latter. So it came that he brought my work to a sudden halt in a manner not too delicate and it took thirty years before I tackled another clockwork again. Shortly thereafter I went into the manufacture of a kind of pop-gun which comprised a hollow tube, a piston, and two plugs of hemp. When firing the gun, the piston was prest against the stomach and the tube was pushed back quickly with both hands. The air between the plugs was comprest and raised to high temperature and one of them was expelled with a loud report. The art consisted in selecting a tube of the proper taper from the hollow stalks which were

(*Continued on page* 843)

MY INVENTIONS

(*Continued from page* 841)

did very well with that gun but my activities interfered with the window panes in our house and met with painful discouragement. If I remember rightly, I then took to carving swords from pieces of furniture which I could conveniently obtain. At that time I was under the sway of the Serbian national poetry and full of admiration for the feats of the heroes. I used to spend hours in mowing down my enemies in the form of corn-stalks which ruined the crops and netted me several spankings from my mother. Moreover these were not of the formal kind but the genuine article.

I had all this and more behind me before I was six years old and had past thru one year of elementary school in the village of Smiljan where I was born. At this juncture we moved to the little city of Gospic nearby. This change of residence was like a calamity to me. It almost broke my heart to part from our pigeons, chickens and sheep, and our magnificent flock of geese which used to rise to the clouds in the morning and return from the feeding grounds at sundown in battle formation, so perfect that it would have put a squadron of the best aviators of the present day to shame. In our new house I was but a prisoner, watching the strange people I saw thru the window blinds. My bashfulness was such that I would rather have faced a roaring lion than one of the city dudes who strolled about. But my hardest trial came on Sunday when I had to dress up and attend the service. There I met with an accident, the mere thought of which made my blood curdle like sour milk for years afterwards. It was my second adventure in a church. Not long before I was entombed for a night in an old chapel on an inaccessible mountain which was visited only once a year. It was an awful experience, but this one was worse. There was a wealthy lady in town, a good but pompous woman, who used to come to the church gorgeously painted up and attired with an enormous train and attendants. One Sunday I had just finished ringing the bell in the belfry and rushed downstairs when this grand dame was sweeping out and I jumped on her train. It tore off with a ripping noise which sounded like a salvo of musketry fired by raw recruits. My father was livid with rage. He gave me a gentle slap on the cheek, the only corporal punishment he ever administered to me but I almost feel it now. The embarrassment and confusion that followed are indescribable. I was practically ostracised until something else happened which redeemed me in the estimation of the community.

An enterprising young merchant had organized a fire department. A new fire engine was purchased, uniforms provided and the men drilled for service and parade. The engine was, in reality, a pump to be worked by sixteen men and was beautifully painted red and black. One afternoon the official trial was prepared for and the machine was transported to the river. The entire population turned out to witness the great spectacle. When all the speeches and ceremonies were concluded, the command was given to pump, but not a drop of water came from the nozzle. The professors and experts tried in vain to locate the trouble. The fizzle was complete when I arrived at the scene. My knowledge of the mechanism was nil and I knew next to nothing of air pressure, but instinctively I felt for the suction hose in the water and found that it had collapsed. When I waded in the river and opened it up the water rushed forth and not a few Sunday clothes were spoiled. Archimedes running naked thru the streets of Syracuse and shouting Eureka at the top of his voice did not make a greater impression than myself. I was carried on the shoulders and was the hero of the day.

Upon settling in the city I began a four-years' course in the so-called Normal School preparatory to my studies at the College or *Real-Gymnasium*. During this period my boyish efforts and exploits, as well as troubles, continued. Among other things I attained the unique distinction of champion crow catcher in the country. My method of procedure was extremely simple. I would go in the forest, hide in the bushes, and imitate the call of the bird. Usually I would get several answers and in a short while a crow would flutter down into the shrubbery near me. After that all I needed to do was to throw a piece of cardboard to detract its attention, jump up and grab it before it could extricate itself from the undergrowth. In this way I would capture as many as I desired. But on one occasion something occurred which made me respect them. I had caught a fine pair of birds and was returning home with a friend. When we left the forest, thousands of crows had gathered making a frightful racket. In a few minutes they rose in pursuit and soon enveloped us. The fun lasted until all of a sudden I received a blow on the back of my head which knocked me down. Then they attacked me viciously. I was compelled to release the two birds and was glad to join my friend who had taken refuge in a cave.

In the schoolroom there were a few mechanical models which interested me and turned my attention to water turbines. I constructed many of these and found great pleasure in operating them. How extraordinary was my life an incident may illustrate. My uncle had no use for this kind of pastime and more than once rebuked me. I was fascinated by a description of Niagara Falls I had perused, and pictured in my imagination a big wheel run by the Falls. I told my uncle that I would go to America and carry out this scheme. Thirty years later I saw my ideas carried out at Niagara and marveled at the unfathomable mystery of the mind.

I made all kinds of other contrivances and contraptions but among these the arbalists I produced were the best. My arrows, when shot, disappeared from sight and at close range traversed a plank of pine one inch thick. Thru the continuous tightening of the bows I developed skin on my stomach very much like that of a crocodile and I am often wondering whether it is due to this exercise that I am able even now to digest cobble-stones! Nor can I pass in silence my performances with the sling which would have enabled me to give a stunning exhibit at the Hippodrome. And now I will tell of one of my feats with this antique implement of war which will strain to the utmost the credulity of the reader. I was practicing while walking with my uncle along the river. The sun was setting, the trout were playful and from time to time one would shoot up into the air, its glistening body sharply defined against a projecting rock beyond. Of course any boy might have hit a fish under these propitious conditions but I undertook a much more difficult task and I foretold to my uncle, to the minutest detail, what I intended doing. I was to hurl a stone to meet the fish, press its body against the rock, and cut it in two. It was no sooner said than done. My uncle looked at me almost scared out of his wits and exclaimed *"Vade retro Satanas!"* and it was a few days before he spoke to me again. Other records, however great, will be eclipsed but I feel that I could peacefully rest on my laurels for a thousand years.

(In the April issue Mr. Tesla will describe in detail how he conceived one of his most important and far reaching inventions: "The Rotary Magnetic Field."—Editor.)

APRIL, 1919
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Vol. VI. Whole No. 72 APRIL, 1919 No. 12

EDITORIAL

Interplanetary Messages

A FEW weeks ago Marconi startled the world by stating that he had often received strong wireless signals which seemed to come from beyond the earth. In a recent interview publisht in the *New York Evening Post* Nikola Tesla, too, reminds us that he had made known to the world years ago the fact that extra-planetary signals were recorded in his Colorado Laboratory. That was in 1899, before the world dreamt of wireless.

Even today announcements such as the above are made light of by editorial writers and others of limited scientific perception. For the earth-bound layman still persists that intelligence can only exist on Earth. Such childish reasoning shows what sort of "intelligence" blossoms on this planet. It never occurs to these reviewers to question why Nature in her Wisdom should have singled out the little speck called Earth, on which to plant beings endowed with reason. Why should there be such an exception? Life in some form or other is certain of being found on myriads of worlds thruout the Universe. And if one world dies, all life does not die with it. Svante Arrhenius shows us how life-bearing spores are carried by the pressure of light thru interstellar space, notwithstanding the absolute zero which prevails there.

In our planetary system, conditions for life, such as we know it, probably only exists on two planets: Mars and Venus. Life on the latter being more or less doubtful, due to its heavy water-laden atmosphere, there remains Mars, a body much older in evolution than the earth. Conditions on Mars we know by direct observation as well as deduction are favorable for life, and we may be certain that it exists there. And if we once grant this, we must also grant that it must have existed for hundreds of thousands of years prior to that on Earth: consequently Martian civilization must be thousands of years ahead of ours.

From this we must deduce again that the Martians probably signaled to us ages ago, when prehistoric man still roamed the forests. But why go so far back? Suppose the Martians had sent us radio messages only thirty years ago. We could never have received them, for we then had no means of recording them. Detectors and audions were undreamt of.

In all this warped logic, we presuppose wireless signals. But why should a civilization so far ahead of ours use—to them—obsolete radio waves, which, like as not, can never hope to bridge 35 million miles! If the Martians are signaling to us, you may be certain that they use an entirely different means than Radio. To be sure, it may turn out to be one of the many wave forms of the ether, but we can only make a poor guess at it today. Meanwhile Martian signals probably fly about our heads day and night, as they may have for thousands of years, but we are still deaf and blind to them. The Martian Wave Detector still remains uninvented. At that the Martians probably have used many methods on us. It is not even impossible that they may have used reflected sun rays. Bell and Tainter in 1880 demonstrated a "wireless" telephone—the Photophone—by making use of a vibrating light ray falling upon a selenium cell. Speech was transmitted over many miles this way. With necessary refinements such a system might bridge interplanetarian space.

As to one planet understanding the other, that is of course child's play. Still, many humorous editorial writers have misgivings on that score. They are afraid that on Mars 2 + 2 might equal, perhaps, 5 or 3, so how could we get together, they ask.

A simple example might serve as an illustration. Suppose an American and a Frenchman, neither knowing the other's language, were connected by a long telegraph line. Both are ignorant of the code. But both have enough sense to tap the key. Suppose both have the desire to enter into communication, what will they do? Tap out dots from one to ten, of course. Thus . . .. etc. It will not take them many months, if they keep at it, to work out a sort of "international" language by means of dots. And the higher their intelligence, the quicker will they understand each other.

That is the basis of interplanetarian communication.

H. GERNSBACK.

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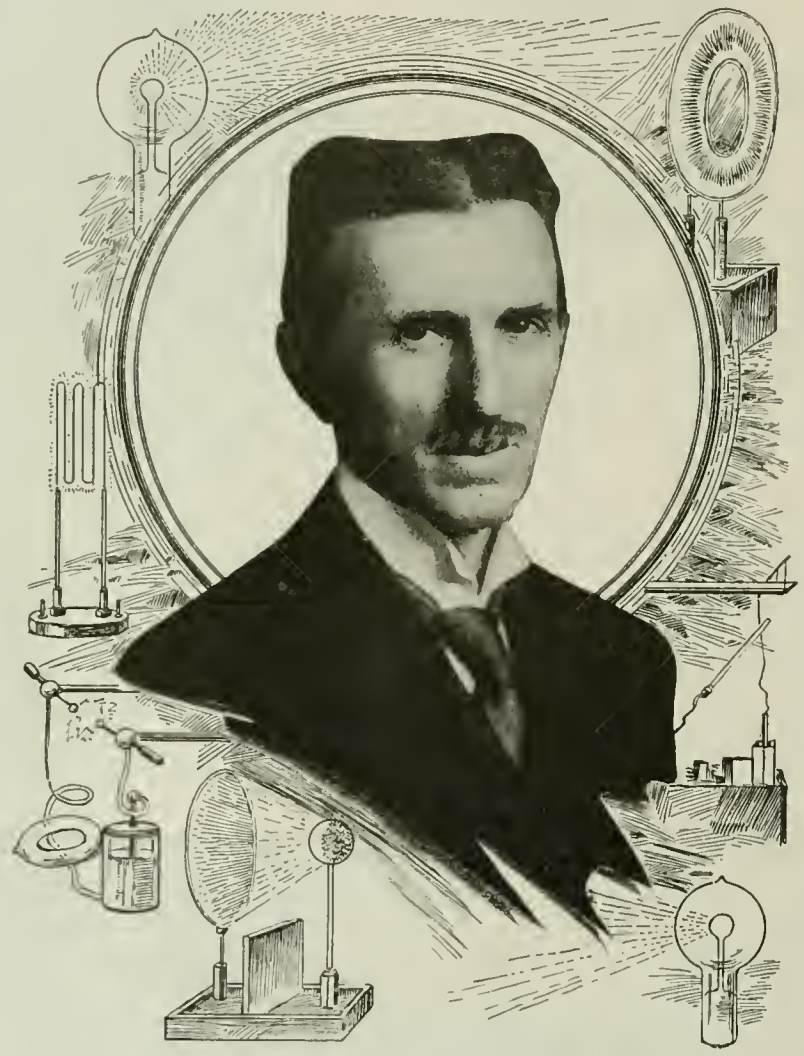
My Inventions

By Nikola Tesla

III. MY LATER ENDEAVORS

The Discovery of the Rotating Magnetic Field

AT the age of ten I entered the Real Gymnasium which was a new and fairly well equipt institution. In the department of physics were various models of classical scientific apparatus, electrical and mechanical. The demonstrations and experiments performed from time to time by the instructors fascinated me and were undoubtedly a powerful incentive to invention. I was also passionately fond of mathematical studies and often won the professor's praise for rapid calculation. This was due to my acquired facility of visualizing the figures and performing the operations, not in the usual intuitive manner, but as in actual life. Up to a certain degree of complexity it was absolutely the same to me whether I wrote the symbols on the board or conjured them before my mental vision. But free-hand drawing, to which many hours of the course were devoted, was an annoyance I could not endure. This was rather remarkable as most of the members of the family excelled in it. Perhaps my aversion was simply due to the predilection I found in undisturbed thought. Had it not been for a few exceptionally stupid boys, who could not do anything at all, my record would have been the worst. It was a serious handicap as under the then existing educational regime, drawing being obligatory, this deficiency threatened to spoil my whole career and my father had considerable trouble in railroading me from one class to another.



Nikola Tesla at 60. A Very Recent Portrait of the Great Inventor. An Excellent Likeness.

In the second year at that institution I became obsest with the idea of producing continuous motion thru steady air pressure. The pump incident, of which I have told, had set afire my youthful imagination and imprest me with the boundless possibilities of a vacuum. I grew frantic in my desire to harness this inexhaustible energy but for a long time I was groping in the dark. Finally, however, my endeavors crystallized in an invention which was to enable me to achieve what no other mortal ever attempted. Imagine a cylinder freely rotatable on two bearings and partly surrounded by a rectangular trough which fits it perfectly. The open side of the trough is closed by a partition so that the cylindrical segment within the enclosure divides the latter into two compartments entirely separated from each other by air-tight sliding joints. One of these compartments being sealed and once for all exhausted, the other remaining open, a perpetual rotation of the cylinder would result, at least, I thought so. A wooden model was constructed and fitted with infinite care and when I applied the pump on one side and actually observed that there was a tendency to turning, I was delirious with joy. Mechanical flight was the one thing I wanted to accomplish altho still under the discouraging recollection of a bad fall I sustained by jumping with an umbrella from the top of a building. Every day I used to transport myself thru the air to distant regions but could not understand just how I managed to do it. Now I had something concrete—a flying machine with nothing more than a rotating shaft, flapping wings, and—a vacuum of unlimited power! From that time on I made my daily aërial excursions in a vehicle of comfort and luxury as might have befitted King Solomon. It took years before I understood that the atmospheric pressure acted at right angles to the surface of the cylinder and that the slight rotary effort I observed was due to a leak. Tho this knowledge came gradually it gave me a painful shock.

I had hardly completed my course at the Real Gymnasium when I was prostrated with a dangerous illness or rather, a score of them, and my condition became so desperate that I was given up by physicians. During this period I was permitted to read constantly, obtaining books from the Public Library which had been neglected and entrusted to me for classification of the works and preparation of the catalogues. One day I was handed a few volumes of new literature unlike anything I had ever read before and so captivating as to make me utterly forget my hopeless state. They were the earlier works of Mark Twain and to them might have been due the miraculous recovery which followed. Twenty-five years later, when I met Mr. Clements and we formed a friendship between us, I told

Mr. Tesla's articles started in our February issue

him of the experience and was amazed to see that great man of laughter burst into tears.

My studies were continued at the higher Real Gymnasium in Carlstadt, Croatia, where one of my aunts resided. She was a distinguished lady, the wife of a Colonel who was an old war-horse having participated in many battles. I never can forget the three years I past at their home. No fortress in time of war was under a more rigid discipline. I was fed like a canary bird. All the meals were of the highest quality and deliciously prepared but short in quantity by a thousand percent. The slices of ham cut by my aunt were like tissue paper. When the Colonel would put something substantial on my plate she would snatch it away and say excitedly to him: "Be careful, Niko is very delicate." I had a voracious appetite and suffered like Tantalus. But I lived in an atmosphere of refinement and artistic taste quite unusual for those times and conditions. The land was low and marshy and malaria fever never left me while there despite of the enormous amounts of quinin I consumed. Occasionally the river would rise and drive an army of rats into the buildings, devouring everything even to the bundles of the fierce paprika. These pests were to me a welcome diversion. I thinned their ranks by all sorts of means, which won me the unenviable distinction of rat-catcher in the community. At last, however, my course was completed, the misery ended, and I obtained the certificate of maturity which brought me to the cross-roads.

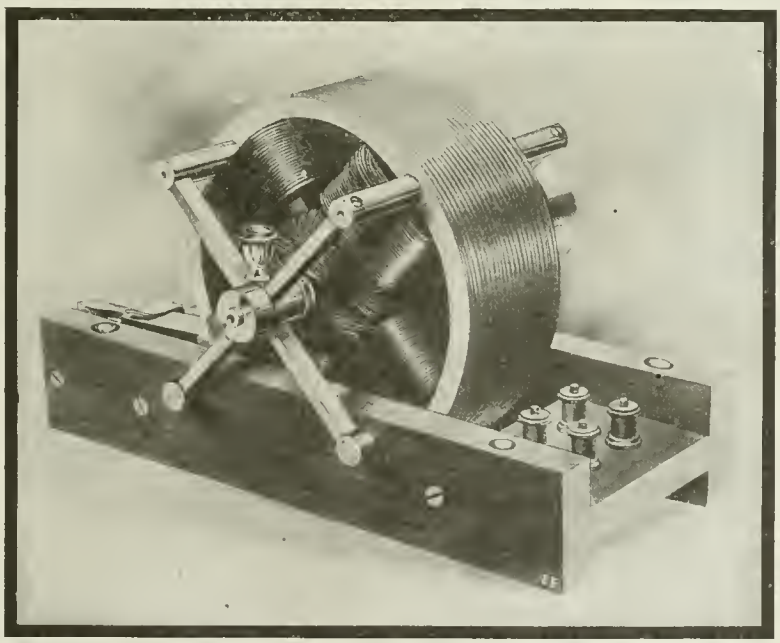
THIS installment, no doubt the most interesting of the three published so far, reveals many extraordinary occurrences and experiences in the world's greatest inventor's life—experiences such as do not fall to the lot of ordinary mortals. And Tesla, the many sided, aside of inventing, knows the rare art of painting word-pictures. He does so here in a masterly fashion. He tells us how he finally conceived the induction motor—perhaps his greatest discovery—the invention which changed the face of the globe, the invention which made possible the street car, the subway, the electric train, power transmission, the harnessing of water falls and countless others. But let Tesla tell you himself how it all came about. It is a classic worth reading. EDITOR.

During all those years my parents never wavered in their resolve to make me embrace the clergy, the mere thought of which filled me with dread. I had become intensely interested in electricity under the stimulating influence of my Professor of Physics, who was an ingenious man and often demonstrated the principles by apparatus of his own invention. Among these I recall a device in the shape of a freely rotatable bulb, with tinfoil coatings, which was made to spin rapidly when connected to a static machine. It is impossible for me to convey an adequate idea of the intensity of feeling I experienced in witnessing his exhibitions of these mysterious phenomena. Every impression produced a thousand echoes in my mind. I wanted to know more of this wonderful force; I longed for experiment and investigation and resigned myself to the inevitable with aching heart.

Just as I was making ready for the long journey home I received word that my father wished me to go on a shooting expedition. It was a strange request as he had been always strenuously opposed to this kind of sport. But a few days later I learned that the cholera was raging in that district and, taking advantage of an opportunity, I returned to Gospic in disregard of my parents' wishes. It is incredible how absolutely ignorant people were as to the causes of this scourge which visited the country in intervals of from fifteen to twenty years. They thought that the deadly agents were transmitted thru the air and filled it with pungent odors and smoke. In the meantime they drank the infected water and died in heaps. I contracted the awful disease on the very day of my arrival and altho surviving the crisis, I was confined to bed for nine months with scarcely any ability to move. My energy was completely exhausted and for the second time I found myself at death's door. In one of the sinking spells which was thought to be the last, my father rushed into the room. I still see his pallid face as he tried to cheer me in tones belying his assurance. "Perhaps," I said, "I may get well if you will let me study engineering." "You will go to the best technical institution in the world." he solemnly replied, and I knew that he meant it. A heavy weight was lifted from my mind but the relief would have come too late had it not been for a marvelous cure brought about thru a bitter decoction of a peculiar bean. I came to life like another Lazarus to the utter amazement of everybody. My father insisted that I spend a year in healthful physical outdoor exercises to which I reluctantly consented. For most of this term I roamed in the mountains, loaded with a hunter's outfit and a bundle of books, and this contact with nature made me stronger in body as well as in mind. I thought and planned, and conceived many ideas almost as a rule delusive. The vision was clear enough but the knowledge of principles was very limited. In one of my inventions I proposed to convey letters and packages across the seas, thru a submarine tube, in spherical containers of sufficient strength to resist the hydraulic pressure. The pumping plant, intended to force the water thru the tube, was accurately figured and designed and all other particulars carefully worked out. Only one trifling detail, of no consequence, was lightly dismist. I assumed an arbitrary velocity of the water and, what is more, took pleasure in making it high, thus arriving at a stupendous performance supported by faultless calculations. Subsequent reflections, however, on the resistance of pipes to fluid flow determined me to make this invention public property.

Another one of my projects was to construct a ring around the equator which would, of course, float freely and could be arrested in its spinning motion by reactionary forces, thus enabling

(*Continued on page* 905)



Tesla's First Induction Motor. This Historic Model is One of the Two First Presented Before the American Institute of Electrical Engineers.

WHAT IS THE INDUCTION MOTOR?

The induction motor operates on alternating current. It has no commutator like a direct current motor, nor slip rings like an alternating current motor. Contrary to the two types just cited the "field" current is not steady, but the current itself rotates constantly pulling around with it—by induction—the only moving part of the motor—the rotor or armature. Having no armature nor slip rings, the induction motor never sparks. It consequently knows no "brush" trouble. It needs no attention because of its ruggedness. Only the bearings wear out. Its efficiency too is higher. On account of all this the induction motor is used in a prepondering proportion in street cars, electric trains, factories, etc.

The Moon's Rotation

By NIKOLA TESLA

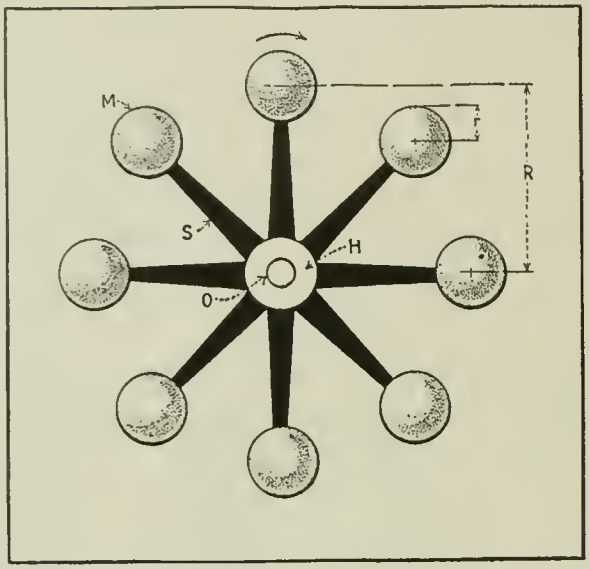
SINCE the appearance of my article entitled the "Famous Scientific Illusions" in your February issue, I have received a number of letters criticizing the views I exprest regarding the moon's "axial rotation." These have been partly answered by my statement to the *New York Tribune* of February 23, which allow me to quote:

In your issue of February 2, Mr. Charles E. Manierre, commenting upon my article in the *Electrical Experimenter* for February which appeared in the *Tribune* of January 26, suggests that I give a definition of axial rotation.

I intended to be explicit on this point as may be judged from the following quotation: "The unfailing test of the spinning of a mass is, however, the existence of *energy of motion*. The moon is not posest of such *vis viva*." By this I meant that "axial rotation" is not simply "rotation upon an axis nonchalantly defined in dictionaries, but is a circular motion in the true physical sense—that is, one in which half the product of the mass with the square of velocity is a definite and positive quantity. The moon is a nearly spherical body, of a radius of about 1,087.5 miles, from which I calculate its volume to be approximately 5,300,216,300 cubic miles. Since its mean density is 3.27, one cubic foot of material composing it weighs close on 205 lbs. Accordingly, the total weight of the satellite is about 79,969,000,000,000,000,000, and its mass 2,483,500,000,000,000,000 terrestrial short tons. Assuming that the moon does physically rotate upon its axis, it performs one revolution in 27 days, 7 hours, 43 minutes and 11 seconds, or 2,360,591 seconds. If, in conformity with mathematical principles, we imagine the entire mass concentrated at a distance from the center equal to two-fifths of the radius, then the calculated rotational velocity is 3.04 feet per second, at which the globe would contain 11,474,000,000,000,000,000 short foot tons of energy sufficient to run 1,000,000,000 horsepower for a period of 1,323 years. Now, I say, that there is not enough of that energy in the moon to run a delicate watch.

In astronomical treatisies usually the argument is advanced that "if the lunar globe did not turn upon its axis it would expose all parts to terrestrial view. As only a little over one-half is visible it *must* rotate." But this inference is erroneous, for it only admits of one alternative. There are an infinite number of axis besides its own in each of which the moon might turn and still exhibit the same peculiarity.

I have stated in my article that the moon rotates about an axis passing thru the center of the earth, which is not strictly true, but it does not vitiate the conclusions I have drawn. It is well known, of course, that the two bodies revolve around a common center of gravity, which is at a distance of a little over 2,899 miles from the earth's center.



If You Still Think That the Moon Rotates on Its Axis, Look at This Diagram and Follow Closely the Successive Positions Taken by One of the Balls M While It Is Rotated by a Spoke of the Wheel. Substitute Gravity for the Spoke and the Analogy Solves the Moon Rotation Riddle.

Another mistake in books on astronomy is made in considering this motion equivalent to that of a weight whirled on a string or in a sling. In the first place there is an essential difference between these two devices tho involving the same mechanical principle. If a metal ball, attached to a string, is whirled around and the latter breaks, an axial rotation of the missile results which is definitely related in magnitude and direction to the motion preceding. By way of illustration—if the ball is whirled on the string clockwise ten times per second, then when it flies off, it will rotate on its axis ten times per second, likewise in the direction of a clock. Quite different are the conditions when the ball is thrown from a sling. In this case a *much more rapid* rotation is imparted to it in the *opposite sense*. There is no true analogy to these in the motion of the moon. *If the gravitational string, as it were, would snap, the satellite would go off in a tangent without the slightest swerving or rotation, for there is no moment about the axis and, consequently, no tendency whatever to spinning motion.*

Mr. Manierre is mistaken in his surmise as to what would happen if the earth were suddenly eliminated. Let us suppose that this would occur at the instant when the moon is in *opposition*. Then it would continue on its eliptical path around the sun, presenting to it steadily the face which was always exposed to the earth. If, on the other hand, the latter would disappear at the moment of *conjunction*, the moon would gradually swing around thru 180° and, after a number of oscillations, revolve, again with the same face to the sun. In either case there would be no periodic changes but eternal day and night, respectively, on the sides turned towards, and away from, the luminary.

Some of the arguments advanced by the correspondents are ingenious and not a few comical. None, however, are valid.

One of the writers imagines the earth in the center of a circular orbital plate, having fixedly attached to its periperal portion a disk-shaped moon, in frictional or geared engagement with another disk of the same diameter and freely rotatable on a pivot projecting from an arm entirely independent of the planetary system. The arm being held continuously parallel to itself, the pivoted disk, of course, is made to turn on its axis as the orbital plate is rotated. This is a well-known drive, and the rotation of the pivoted disk is as palpable a fact as that of the orbital plate. But, the moon in this model only revolves about the center of the system *without the slightest angular displacement* on its own axis. The same is true of a cart-wheel to which this writer refers. So long as it advances on the earth's surface it turns on the axle in the true physical sense; when one of its spokes is always kept in a perpendicular position the wheel still *revolves* about the earth's center, *but axial rotation has ceased*. Those who think that it then still exists are laboring under an illusion.

An obvious fallacy is involved in the following abstract reasoning. The orbital plate is assumed to gradually shrink, so that finally the centers of the earth and the satellite coincide when the latter revolves simultaneously about its own and the earth's axis. We may reduce the earth to a mathematical point and the distance between the two planets to the radius of the moon without affecting the system in principle, but a further diminution of the distance is mani- (*Cont. on p.* 892)

WE believe the accompanying illustration and its explanation will dispel all doubts as to whether the moon rotates on its axis or not. Each of the balls, as M, depicts a different position of, and rotates exactly like, the moon keeping always the same face turned towards the center O, representing the earth.

But as you study this diagram, can you conceive that any of the balls turn on their axis? Plainly this is rendered physically impossible by the spokes. But if you are still unconvinced, Mr. Tesla's experimental proof will surely satisfy you. A body rotating on its axis must contain rotational energy. Now it is a fact, as Mr. Tesla shows, that no such energy is imparted to the ball as, for instance, to a projectile discharged from a gun. It is therefore evident that the moon, in which the gravitational attraction is substituted for a spoke, cannot rotate on its axis or, in other words, contain rotational energy. If the earth's attraction would suddenly cease and cause it to fly off in a tangent, the moon would have no other energy except that of translatory movement, and it would not spin like the ball.—Editor.

The Moon's Rotation

(*Continued from page 866*)

festly absurd and of no bearing on the question under consideration.

In all the communications I have received, tho different in the manner of presentation, the successive changes of position in space are mistaken for axial rotation. So, for instance, a positive refutation of my arguments is found in the observation that the moon exposes all sides to other planets! It revolves, to be sure, but none of the evidences is a proof that it turns on its axis. Even the well-known experiment with the Foucault pendulum, altho exhibiting similar phenomena as on our globe, would merely demonstrate a motion of the satellite about *some* axis. The view I have advanced is NOT BASED ON A THEORY but on facts *demonstrable by experiment*. It is not a matter of *definition* as some would have it. A MASS REVOLVING ON ITS AXIS MUST BE POSEST OF MOMENTUM. If it has none, there is no axial rotation, all appearances to the contrary notwithstanding.

A few simple reflections based on well establisht mechanical principles will make this clear. Consider first the case of two equal weights w and w_1, in Fig. 1, whirled about the center O on a string s as shown. Assuming the latter to break at a both weights will fly off on tangents to their circles of gyration, and, being animated with different velocities, they will rotate around their common center of gravity o. If the weights are whirled n times per second then the speed of the outer and the inner one will be, respectively, $V = 2(R + r)n$ and $V_1 = 2\pi(R - r)n$, and the difference $V - V_1 = 4\pi rn$, will be the length of the circular path of the outer weight. Inasmuch, however, as there will be equalization of the speeds until the mean value is attained, we shall have $\frac{V - V_1}{2} = 2\pi rn = 2\pi rN$, N being the number of revolutions per second of the weights around their center of gravity. Evidently then, the weights continue to rotate at the original rate and in the same direction. I know this to be a fact from actual experiments. It also follows that a ball, as that shown in the figure, will behave in a similar manner for the two half-spherical masses can be concentrated at their centers of gravity and m and m_1, respectively, which will be at a distance from o equal to $\frac{1}{8}r$.

This being understood, imagine a number of balls M carried by as many spokes S radiating from a hub H, as illustrated in Fig. 2, and let this system be rotated n times per second around center O on frictionless bearings. A certain amount of work will be required to bring the structure to this speed, and it will be found that it equals exactly half the product of the masses with the square of the tangential velocity. Now if it be true that the moon rotates in reality on its axis *this must also hold good for EACH of the balls as it performs the same kind of movement*. Therefore, in imparting to the system a given velocity, energy must have been used up in the axial rotation of the balls. Let M be the mass of one of these and R the radius of gyration, then the rotational energy will be $E = \frac{1}{2}M(2\pi Rn)^2$. Since for one complete turn of the wheel every ball makes one revolution on its axis, according to the prevailing theory, the energy of axial rotation of each ball will be $e = \frac{1}{2}M(2\pi r_1 n)^2$, r_1 being the radius of gyration about the axis and equal to 0.6325 r. We can use as large balls as we like, and so make e a considerable percentage of E and yet, it is positively established by experiment that each of the rotating balls contain only the energy E, no power whatever being consumed in the supposed axial rotation, which is, consequently, wholly illusionary. Something even more interesting may, however, be stated. As I have shown before, a ball flying off will rotate at the rate of the wheel and in the same direction. But this whirling motion, unlike that of a projectile, neither adds to, nor detracts from, the energy of the translatory movement which is exactly equal to the work consumed in giving to the mass the observed velocity.

From the foregoing it will be seen that in order to make one physical revolution on its axis the moon should have twice its present angular velocity, and then it would contain a quantity of stored energy as given in my above letter to the *New York Tribune*, on the assumption that the radius of gyration is 2/5 that of figure. This, of course, is uncertain, as the distribution of density in the interior is unknown. But from the character of motion of the satellite it may be concluded with certitude *that it is devoid of momentum about its axis.* If it be bisected by a plane tangential to the orbit, the masses of the two halves are inversely as the distances of their centers of gravity from the earth's center and, therefore, if the latter were to disappear suddenly, no axial rotation, as in the case of a weight thrown off, would ensue.

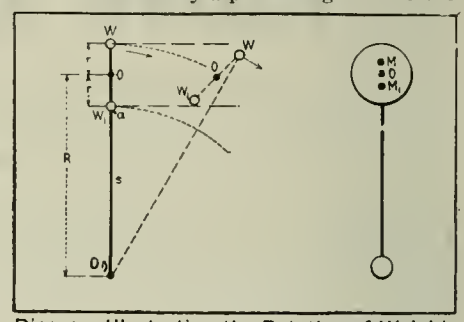


Diagram Illustrating the Rotation of Weights Thrown Off By Centrifugal Force.

WHAT IS MAN?

A man weighing 150 pounds will contain approximately 3,500 cubic feet of gas,—oxygen, hydrogen and nitrogen in his constitution, which at eighty cents per thousand cubic feet would be worth $2.80 for illuminating purposes. He also contains all the necessary fats to make a 15-pound candle, and thus, together with his 3,500 cubic feet of gases, he possesses considerable *illuminating* possibilities. His system contains 22 pounds and ten ounces of carbon, or enough to make 780 dozen, or 9,360 lead pencils. There are about fifty grains of iron in his blood and the rest of the body would supply enough of this metal to make one spike large enough to hold his weight. A healthy man contains 54 ounces of phosphorus. This deadly poison would make 800,000 matches, or enough poison to kill five hundred persons. This, with two ounces of lime, make the stiff bones and brains. No difference how *sour* a man looks, he contains about 60 lumps of sugar of the ordinary cubical dimensions, and to make the seasoning complete, there are 20 *spoonfuls of salt*. If a man were distilled into water, he would make about 38 quarts, or more than half his entire weight. He also contains a great deal of starch, chlorid of potash, magnesium, sulfur, and hydrochloric acid in his wonderful human system.

Break the shells of 1,000 eggs into a huge pan or basin, and you have the contents to make a man from his toe-nails to the most delicate tissues of his brain. And this is the scientific answer to the question, "What is Man?"

teresting incident. He wished to make the apparition of a young lady appear to a lieutenant living several miles away. At the time of the experiment a visitor happened to be with the lieutenant, who is said to have seen the apparition also. Many instances are recorded in which persons were hypnotized at some distance. All of these phenomena can be easily explained by the *brain wave* theory.

Besides the transference of thought, both sympathy and affection may be the outgrowth of these radiations from the brain. Whether our capacity for the reception of these impulses is increasing with the evolution of man, cannot be ascertained directly. It would seem probable, however, that with our increase in education and civilization that a conscious use of this *thought language* may be found. Who knows but that the man of the future may find a practical application for this radiation from the brain, and a higher and more delicately made creature may result who would effect mutual understanding by means of this marvelous and as yet but little understood *psychical activity.*

MY INVENTIONS

(*Continued from page* 865)

travel at a rate of about one thousand miles an hour, impracticable by rail. The reader will smile. The plan was difficult of execution, I will admit, but not nearly so bad as that of a well-known New York professor, who wanted to pump the air from the torrid to the temperate zones, entirely forgetful of the fact that the Lord had provided a gigantic machine for this very purpose.

Still another scheme, far more important and attractive, was to derive power from the rotational energy of terrestrial bodies. I had discovered that objects on the earth's surface, owing to the diurnal rotation of the globe, are carried by the same alternately in and against the direction of translatory movement. From this results a great change in momentum which could be utilized in the simplest imaginable manner to furnish motive effort in any habitable region of the world. I cannot find words to describe my disappointment when later I realized that I was in the predicament of Archimedes, who vainly sought for a fixt point in the universe.

At the termination of my vacation I was sent to the Polytechnic School in Gratz, Styria, which my father had chosen as one of the oldest and best reputed institutions. That was the moment I had eagerly awaited and I began my studies under good auspices and firmly resolved to succeed. My previous training was above the average, due to my father's teaching and opportunities afforded. I had acquired the knowledge of a number of languages and waded thru the books of several libraries, picking up information more or less useful. Then again, for the first time, I could choose my subjects as I liked, and free-hand drawing was to bother me no more. I had made up my mind to give my parents a surprise, and during the whole first year I regularly started my work at three o'clock in the morning and continued until eleven at night, no Sundays or holidays excepted. As most of my fellow-students took things easily, naturally enough I eclipsed all records. In the course of that year I past thru nine exams and the professors thought I deserved more than the highest qualifications. Armed with their flattering certificates, I went home for a short rest, expecting a triumph, and was mortified when my father made light of these hard-won honors. That almost killed my ambition; but later, after he had died, I was pained to find a package of letters which

(*Continued on page* 907)

MY INVENTIONS.

(*Continued from page* 905)

the professors had written him to the effect that unless he took me away from the Institution I would be killed thru overwork. Thereafter I devoted myself chiefly to physics, mechanics and mathematical studies, spending the hours of leisure in the libraries. I had a veritable mania for finishing whatever I began, which often got me into difficulties. On one occasion I started to read the works of Voltaire when I learned, to my dismay, that there were close on one hundred large volumes in small print which that monster had written while drinking seventy-two cups of black coffee per diem. It had to be done, but when I laid aside the last book I was very glad, and said, "Never more!"

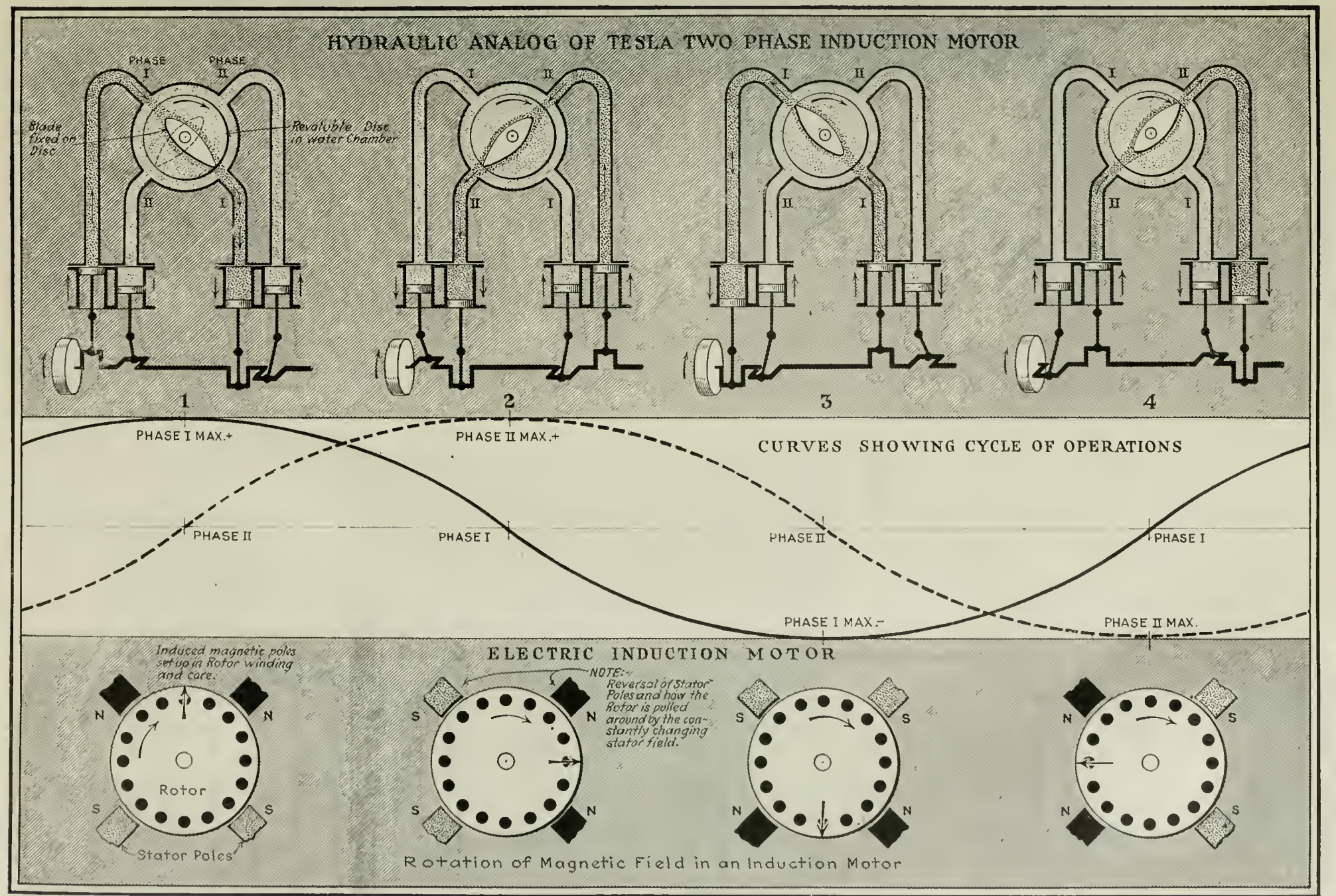
My first year's showing had won me the appreciation and friendship of several professors. Among these were Prof. Rogner, who was teaching arithmetical subjects and geometry; Prof. Poeschl, who held the chair of theoretical and experimental physics, and Dr. Allé, who taught integral calculus and specialized in differential equations. This scientist was the most brilliant lecturer to whom I ever listened. He took a special interest in my progress and would frequently remain for an hour or two in the lecture room, giving me problems to solve, in which I delighted. To him I explained a flying machine I had conceived, not an illusionary invention, but one based on sound, scientific principles, which has become realizable thru my turbine and will soon be given to the world. Both Professors Rogner and Poeschl were curious men. The former had peculiar ways of expressing himself and whenever he did so there was a riot, followed by a long and embarrassing pause. Prof. Poeschl was a methodical and thoroly grounded German. He had enormous feet and hands like the paws of a bear, but all of his experiments were skillfully performed with clock-like precision and without a miss.

It was in the second year of my studies that we received a Gramme dynamo from Paris, having the horseshoe form of a laminated field magnet, and a wire-wound armature with a commutator. It was connected up and various effects of the currents were shown. While Prof. Poeschl was making demonstrations, running the machine as a motor, the brushes gave trouble, sparking badly, and I observed that it might be possible to operate a motor without these appliances. But he declared that it could not be done and did me the honor of delivering a lecture on the subject, at the conclusion of which he remarked: "Mr. Tesla may accomplish great things, but he certainly never will do this. It would be equivalent to converting a steadily pulling force, like that of gravity, into a rotary effort. It is a perpetual motion scheme, an impossible idea." But instinct is something which transcends knowledge. We have, undoubtedly, certain finer fibers that enable us to perceive truths when logical deduction, or any other willful effort of the brain, is futile. For a time I wavered, imprest by the professor's authority, but soon became convinced I was right and undertook the task with all the fire and boundless confidence of youth.

I started by first picturing in my mind a direct-current machine, running it and following the changing flow of the currents in the armature. Then I would imagine an alternator and investigate the processes taking place in a similar manner. Next I would visualize systems comprising motors and generators and operate them in various ways. The images I saw were to me perfectly real and tangible. All my remaining term in Gratz was past in intense but fruitless efforts of this kind, and I almost came to the conclusion that the problem was insolvable. In 1880 I went to Prague, Bohemia, carrying out my father's wish to complete my education at the University there. It was in that city that I made a decided advance, which consisted in detaching the commutator from the machine and studying the phenomena in this new aspect, but still without result. In the year following there was a sudden change in my views of life. I realized that my parents had been making too great sacrifices on my account and resolved to relieve them of the burden. The wave of the American telephone had just reached the European continent and the system was to be installed in Budapest, Hungary. It appeared an ideal opportunity, all the more as a friend of our family was at the head of the enterprise. It was here that I suffered the complete breakdown of the nerves to which I have referred. What I experienced during the period of that illness surpasses all belief. My sight and hearing were always extraordinary. I could clearly discern objects in the distance when others saw no trace of them. Several times in my boyhood I saved the houses of our neighbors from fire by hearing the faint crackling sounds which did not disturb their sleep, and calling for help.

In 1899, when I was past forty and carrying on my experiments in Colorado, I could hear very distinctly thunderclaps at a distance of 550 miles. The limit of audition for my young assistants was scarcely more than 150 miles. My ear was thus over thirteen times more sensitive. Yet at that time I was, so to speak, stone deaf in comparison with the acuteness of my hearing while under the nervous strain. In Budapest I could hear the ticking of a watch with three rooms between me and the time-piece. A fly alighting on a table in the room would cause a dull thud in my ear. A carriage passing at a distance of a few miles fairly shook my whole body. The whistle of a locomotive twenty or thirty miles away made the bench or chair on which I sat vibrate so strongly that the pain was unbearable. The ground under my feet trembled continuously. I had to support my bed on rubber cushions to get any rest at all. The roaring noises from near and far often produced the effect of spoken words which would have frightened me had I not been able to resolve them into their accidental components. The sun's rays, when periodically intercepted, would cause blows of such force on my brain that they would stun me. I had to summon all my will power to pass under a bridge or other structure as I experienced a crushing pressure on the skull. In the dark I had the sense of a bat and could detect the presence of an object at a distance of twelve feet by a peculiar creepy sensation on the forehead. My pulse varied from a few to two hundred and sixty beats and all the tissues of the body with twitchings and tremors which was perhaps the hardest to bear. A renowned physician who gave me daily large doses of Bromid of Potassium pronounced my malady unique and incurable. It is my eternal regret that I was not under the observation of experts in physiology and psychology at that time. I clung desperately to life, but never expected to recover. Can anyone believe that so hopeless a physical wreck could ever be transformed into a man of astonishing strength and tenacity, able to work thirty-eight years almost without a day's interruption, and find himself still strong and fresh in body and mind? Such is my case. A powerful desire to live and to continue the work, and the assistance of a devoted friend and athlete accomplished the wonder. My health returned and with it the vigor of mind. In attacking the problem again I almost regretted that the struggle was soon to end. I had so much energy to spare. When I undertook the task it was not with a resolve such as men often make. With me it was a sacred vow, a question of life and death. I knew that I would perish if I failed. Now I felt that the battle

(*Continued on page* 909)



The Purpose of This Analog Is to Portray, As Faithfully As Possible, the Phenomena of Tesla's Rotating Magnetic Field So As to Make Them Easily Understandable to the Average Reader. The Two Alternating Fluxes Are Represented By Streams of Water Having the Same Relation As to Phase, Amplitude and Direction. The Magnetic Polarity of the Rotor Is Imitated By the Employment of a Body So Shaped As to Behave, With Respect to the Streams, Exactly As the Rotor With Respect to the Poles. Moreover, the Corresponding Rotating and Stationary Parts Are Given a Similar Appearance and Are Disposed In Like Manner. To Make the Analog Complete, It May Further Be Assumed That the Liquid Is Compressible So That There Will Be a Phase Displacement Between Pressure and Flow As That Existing Between Electro-Motive Force and Current.

MY INVENTIONS.

(*Continued from page* 907)

was won. Back in the deep recesses of the brain was the solution, but I could not yet give it outward expression. One afternoon, which is ever present in my recollection, I was enjoying a walk with my friend in the City Park and reciting poetry. At that age I knew entire books by heart, word for word. One of these was Göcthe's "Faust." The sun was just setting and reminded me of the glorious passage:

"Sie rückt und weicht, der Tag ist überlebt,
Dort eilt sie hin und fördert neues Leben.
Oh, dass kein Flügel mich vom Boden hebt
*Ihr nach und immer nach zu streben!**

* * * * * * *

Ein schöner Traum indessen sie entweicht,
Ach, zu des Geistes Flügeln wird so leicht
Kein körperlicher Flügel sich gesellen!"†

As I uttered these inspiring words the idea came like a flash of lightning and in an instant the truth was revealed. I drew with a stick on the sand the diagrams shown six years later in my address before the American Institute of Electrical Engineers, and my companion understood them perfectly. The images I saw were wonderfully sharp and clear and had the solidity of metal and stone, so much so that I told him: "See my motor here; watch me reverse it." I cannot begin to describe my emotions. Pygmalion seeing his statue come to life could not have been more deeply moved. A thousand secrets of nature which I might have stumbled upon accidentally I would have given for that one which I had wrested from her against all odds and at the peril of my existence.

* "The glow retreats, done is the day of toil;
It yonder hastes, new fields of life exploring;
Ah, that no wing can lift me from the soil,
Upon its track to follow, follow soaring!"

† A glorious dream! though now the glories fade.
Alas! the wings that lift the mind no aid
Of wings to lift the body can bequeath me."

TESLA ON HIGH FREQUENCY GENERATORS.

Editor, ELECTRICAL EXPERIMENTER:

It is to be regretted that a letter addrest to me by Mr. J. Harris Rogers, in your care, was published in the march number of the ELECTRICAL EXPERIMENTER, altho the concurrence of our views in some wireless features might have made this desirable to so wide-awake and enterprising a periodical as yours.

Mr. Rogers seems to be a very appreciative gentleman and nothing would be farther from my thoughts than to detract anything from his merit, but in a separate contribution, which I expect to prepare for your next issue, I shall express myself on this subject without prejudice and in the interest of truth. However, the article by your Mr. H. Winfield Secor on "America's Greatest War Invention—The Rogers Underground Wireless" contains a reference to "a novel and original high frequency generator" of Mr. Rogers' invention. May I not —to use the President's elegant expression —call attention to the fact that this device was described by me years ago, as will be evident from the following excerpt of a communication which appeared in the *Electrical Review* of March 15, 1899. In speaking of circuit controllers, I said: "I may mention here, based on a different principle, which is incomparably more effective, more efficient, and also simpler on the whole. It comprises a fine stream of conducting fluid which is made to issue, with any desired speed, from an orifice connected with one pole of a generator, thru the primary of the induction coil, against the other terminal of the generator placed at a small distance. This device gives discharges of a remarkable suddenness, and the frequency may be

(*Continued on page* 914)

Acetylene Bunsen Burner.

(312) Richard E. Mathes, Excelsior, Minn., writes: "I have devised a scheme whereby an acetylene gas plant for bunsen burners and gas in a small chemical laboratory may be installed at very low cost. This is meant especially for the amateur who does not have gas in his home. Is this practical? Could I sell a patent for it? If so, what would it be worth? Could I use an ordinary bunsen burner as part of the patent without infringement?"

A. We see nothing fundamentally new about this idea, as burners of this kind have been used for years, and such a device is well known in the art. We are quite positive that a patent could not be obtained upon it.

Double Lock.

(313) Chas. H. Morgan, Newton, Iowa, sends in an idea on a Double Hasp Lock which can be operated from both sides of the door. He wants to know if this device can be patented.

A. We see nothing fundamentally new in this, and furthermore doubt the utility of the device. We also doubt if a patent can be obtained on it.

Envelope.

(314) José Mata, San Francisco, Cal., submits a sample of an envelope. He wishes us to give him our advice if such an envelope could be patented and if it is feasible. As will be noted, a string with a knot at each end is glued into the envelope when made.

A. This is a good idea but it is not new. Similar devices have been on the market for a long time, and some years ago very many magazines used a string of this kind to open up the mailing wrapper, simply by having a thread incorporated into the magazine wrapper. This thread was pulled in a similar fashion as the string of our correspondent's envelope. We are positive no patent can be obtained on this device.

Automatic Fuse Replacer.

(315) Wm. Sambur, New York City, says: "I would like to know if an automatic fuse replacer which instantly inserts new fuses after extracting burnt out fuses would be patentable. This device could be manufactured at a cost of $3.00. Would this be a good selling article? I await anxiously the next issue of the ELECTRICAL EXPERIMENTER for my answer."

A. Without having the necessary details, it is impossible for us to give advice. Correspondents should bear in mind that merely by giving vague indications, it is extremely dangerous for us to give advice as well as for correspondents to accept it.

Smoke Stack.

(316) Walter A. Buckheim, Boulder, Colo., asks us: "Please let me know thru your magazine if the following idea is patentable. It is desired to construct a chimney or factory smoke stack with rifles or vanes which will impart a rotary motion to the escaping gases. In forced draft plants the gases can be given a rotary motion by mechanical means. In this way a miniature whirlwind will be created which will hold the gases in a narrow column and carry them to a great height, where especially, if they are poisonous, they will be out of everyone's way. The gases will in effect pass thru a chimney made of air."

A. This is a clever idea, but it has one great fault, namely, it won't work. No matter what arrangement were used and even if you were to expend 10,000 H. P. to push the gases out of the smoke stack, if a moderately strong wind was blowing the gases would positively be forced sidewise, and if the wind was blowing earthward, the gases in this case would be blown earthward too. You cannot hope to raise a gaseous column into the air and prevent its swaying sidewise by any known means. For this reason smelters and chemical industries having to do with poisonous gases build their chimneys as high as possible. There are some cases known where a chimney has actually been laid up the side of a moderate mountain in order to let the gases escape at the top as far away from human habitation as possible.

Radio Break-In System.

(317) C. E. Mitchell, Miami, Fla., submits for our advice the following idea: "I have a break-in system for use in wireless telegraphy that does away with anchor gaps and other troublesome apparatus used in break-in systems. It consists of the ordinary heavy wireless key, with an attachment at the rear, working something similar to a compound lever. When the key is raised the antenna is connected to the receiver, the detector unshorted, and circuit to power transformer opened. In this manner the receiver is always in a receptive condition at the instant the key is raised. The idea provides for an extension in length to the ordinary wireless key and may be installed in any circuit with ease and does not hamper the pressure adjustment of the key. This means of break-in will prevent considerable interference and loss of time.

A. This is not at all a new idea and the Patent Office is full of break-in systems of this kind. A great many similar ones have been described in the past volumes of the ELECTRICAL EXPERIMENTER. Many of these systems are very good, as is our correspondent's, and many are actually in use, particularly amateurs seem to like them.

NEW PULL SOCKET HAS CURRENT TAP.

In many cases it is desirable to connect an electrical appliance to a single-lamp wall bracket or ceiling fixture without interfering with the lamp. A very convenient way for doing this has been provided by means of the new pull socket current tap illustrated. It is a combination pull socket and plug receptacle built into a single compact body. It is also supplied with a ⅛", ¼", ⅜" or pendent cap. The pull chain controls the current to the lamp socket proper, whereas the terminals of the receptacle in the side of the body are continuously in circuit.

An advantage that this type of socket gives is that it eliminates the annoyance of the long cord running from side-wall outlets. By means of the new fitting, current can be supplied directly below the fixture to operate various table appliances or other portable devices such as are in general use, without sacrificing the use of light from the lamp itself. It thus eliminates the annoyance of groping about in the dark while trying to plug into the socket.

AERONAUTICAL EXPOSITION AT NEW YORK.

Army Day at the Aeronautical Exposition in Madison Square Garden and the 69th Regiment Armory, New York City, brought several thousand uniformed spectators at the afternoon and evening sessions. Secretary of War Newton D. Baker was to have been the guest of honor, but at the last minute he notified the officials of the exposition that he had been summoned by the President for a conference. Major General Thomas Barry, Commandant of the Department of the East, accompanied by members of his staff, represented the Secretary of War.

At the wireless telephone exhibit in the 69th Regiment Armory, Lieutenant J. F. Adams entertained the spectators by reading news from a daily newspaper to ships in the harbor and places on land equipt with apparatus. The spectators, by means of a sounding horn, were able to hear the answers he received.

Brigadier General Guy Livingston, who represented the British Air Ministry in this country, was an interested spectator at the afternoon session. He said that he believed the Atlantic would be crost by airplane or dirigible within the next two or three months.

TESLA ON HIGH FREQUENCY GENERATORS.

(*Continued from page* 909)

brought within reasonable limits, almost to anything desired. I have used this device for a long time in connection with ordinary coils and in a form of my own coil with results greatly superior in every respect to those obtainable with the form of your letter, make a few statements referring to such make-and-break devices in general, and various forms based on this new principle."

I may add that a great many forms of this apparatus were constructed and employed by me for a long time, proving very convenient and useful. Water does not give particularly good results, being incapable of causing very abrupt changes, but electrolytes have the property of diminishing enormously in resistance when they are heated and the effects are much more intense. Salts of lithium are especially efficient.

NIKOLA TESLA.

New York, February 20, 1919.

MAY, 1919
20 Cts.

ELECTRICAL EXPERIMENTER

SCIENCE AND INVENTION

OVER 175 ILLUST.

THE THOUGHT RECORDER

See Page 12

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Practical Science

THE wonderful age in which we are living has never been paralleled in history. We have more comforts, more conveniences, more of everything than human beings ever had, since the creation of the world. Nevertheless, our lives become more and more complex, as time rolls on, while the average human being becomes more perplexed at the strange surroundings in which he finds himself.

Our electro-mechanical age brings forth new surprises constantly, and he who does not know the rudimentaries of mechanics, electricity and general physics is like a blind man in a circus. He hears what is going on, but all is meaningless to him—he cannot get the full benefit of the performance.

Where humanity now finds itself surrounded by machines, and by electrical wires at every hand, it behooves every man to know something about them. Thousands of lives are lost every year because laymen refuse to learn a little about science in general. They get killed because they fight short-circuits with water, when ten minutes of study would have told them that water is a conductor, and that a few handfuls of dry sand—which is a non-conductor—would have saved the life, *and* the house which burnt down due to the short-circuit. If the father had told his boy that a wet rope is a good conductor for electricity that boy would be alive today. Instead, the boy threw the wet rope over the high tension line, while holding it in his hand, and was killed.

If the six hundred auto owners who were asphyxiated last year—the casualties become larger each year—had known a bit of chemistry, they, too, would be living today. But they insisted upon running their engines in a garage with closed doors, and unfortunately, you can't smell carbon monoxid, even if it is deadly.

Then, too, hundreds of people perish in snow storms every year quite unnecessarily. Usually they freeze to death. The white man runs about in a frenzy when he knows himself lost. He becomes overheated, and the perspiration soaks his clothing. Finally he sinks down into the snow, exhausted, and if it is cold enough he is soon frozen stiff. Now Eskimos, who have learned a bit of science by hard experience, prefer to live pleasantly thru the worst snowstorm, with the temperature below zero. If the Eskimo becomes lost in the wilderness he knows better than to run about aimlessly. He promptly digs a cave into the snow, with the entrance away from the wind, using only his hands for tools. Inside of ten minutes he is safely ensconced in a comparatively warm shelter. He then closes up the entrance almost entirely, sits down, drops his head on his knees, and has a refreshing sleep. The next morning he digs himself out, and is on his way.

If the writer had not known something about electricity, he, too, might not be here to write these lines. As a boy he went down into an unoccupied cellar. The wind blew the wooden door shut, locking him in, as the iron latch was outside. The only other exit was an open window hole barricaded with stout iron rods, thru which the wind roared. The temperature was below zero. The cellar was empty, save for a few wooden crates, the object of the visit. The cellar being distant from the house and other habitations, the parents away, and the caretaker off for the night, there was every possibility of his freezing to death. No tools to break down the door, no matches to make a fire. But there was a portable light, with two large electric dry cells in a wooden box, which the writer had brought along to light his way.

He unraveled the stranded electric cord and extracted a single thin copper strand an inch long. With this he short-circuited the dry cells. The wire became white hot. A piece of paper was touched to it, which burst into flame; a broken piece of crate wood was ignited by the flame, and a fire soon roared. A burning crate set the cellar door on fire, and in ten minutes the adventure had come to a close.

H. GERNSBACK.

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My Inventions

By Nikola Tesla

IV. The Discovery of the Tesla Coil and Transformer

FOR a while I gave myself up entirely to the intense enjoyment of picturing machines and devising new forms. It was a mental state of happiness about as complete as I have ever known in life. Ideas came in an uninterrupted stream and the only difficulty I had was to hold them fast. The pieces of apparatus I conceived were to me absolutely real and tangible in every detail, even to the minutest marks and signs of wear. I delighted in imagining the motors constantly running, for in this way they presented to the mind's eye a more fascinating sight. When natural inclination develops into a passionate desire, one advances towards his goal in seven-league boots. In less than two months I evolved virtually all the types of motors and modifications of the system which are now identified with my name. It was, perhaps, providential that the necessities of existence commanded a temporary halt to this consuming activity of the mind. I came to Budapest prompted by a premature report concerning the telephone enterprise and, as irony of fate willed it, I had to accept a position as draftsman in the Central Telegraph Office of the Hungarian Government at a salary which I deem it my privilege not to disclose! Fortunately, I soon won the interest of the Inspector-in-Chief and was thereafter employed on calculations, designs and estimates in connection with new installations, until the Telephone Exchange was started, when I took charge of the same. The knowledge and practical experience I gained in the course of this work was most valuable and the employment gave me ample opportunities for the exercise of my inventive faculties. I made several improvements in the Central Station apparatus and perfected a telephone repeater or amplifier which was never patented or publicly described but would be creditable to me even today. In recognition of my efficient assistance the organizer of the undertaking, Mr. Puskas, upon disposing of his business in Budapest, offered me a position in Paris which I gladly accepted.

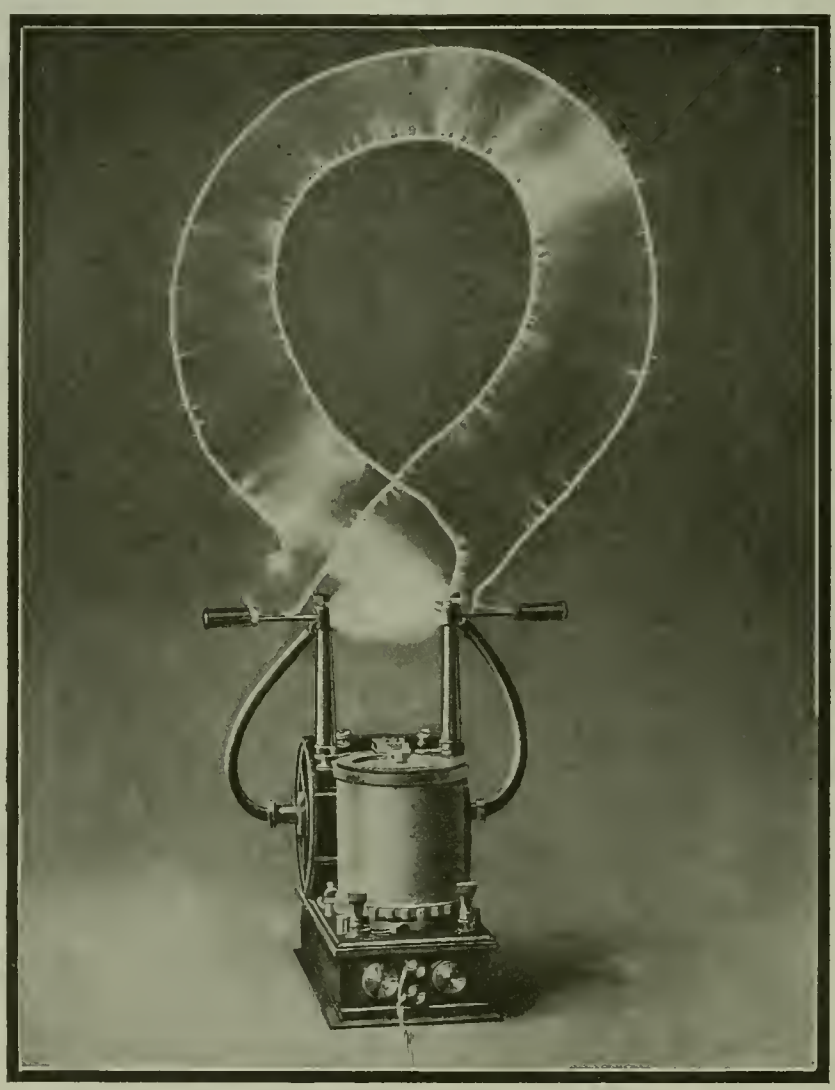


Fig. 1—Tesla Oscillation Transformer (Tesla Coil) Presented by Lord Kelvin Before the British Association in August, 1897. This Small and Compact Instrument, Only 8 Inches High, Developed Two Square Feet of Streamers With Twenty-Five Watts From the 110 Volt D. C. Supply Circuit. The Instrument Contains a Tesla Primary and Secondary, Condenser, and a Circuit Controller.

I never can forget the deep impression that magic city produced on my mind. For several days after my arrival I roamed thru the streets in utter bewilderment of the new spectacle. The attractions were many and irresistible, but, alas, the income was spent as soon as received. When Mr. Puskas asked me how I was getting along in the new sphere, I described the situation accurately in the statement that "the last twenty-nine days of the month are the toughest!" I led a rather strenuous life in what would now be termed "Rooseveltian fashion." Every morning, regardless of weather, I would go from the Boulevard St. Marcel, where I resided, to a bathing house on the Seine, plunge into the water, loop the circuit twenty-seven times and then walk an hour to reach Ivry, where the Company's factory was located. There I would have a woodchopper's breakfast at half-past seven o'clock and then eagerly await the lunch hour, in the meanwhile cracking hard nuts for the Manager of the Works, Mr. Charles Batchellor, who was an intimate friend and assistant of Edison. Here I was thrown in contact with a few Americans who fairly fell in love with me because of my proficiency in—billiards. To these men I explained my invention and one of them, Mr. D. Cunningham, Foreman of the Mechanical Department, offered to form a stock company. The proposal seemed to me comical in the extreme. I did not have the faintest conception of what that meant except that it was an American way of doing things. Nothing came of it, however, and during the next few months I had to travel from one to another place in France and Germany to cure the ills of the power plants. On my return to Paris I submitted to one of the administrators of the Company, Mr. Rau, a plan for improving their dynamos and was given an opportunity. My success was complete and the delighted directors accorded me the privilege of developing automatic regulators which were much desired. Shortly after there was some trouble with the lighting plant which has been installed at the new rail-

Mr. Tesla's articles started in our February issue

road station in Strassburg, Alsace. The wiring was defective and on the occasion of the opening ceremonies a large part of a wall was blown out thru a short-circuit right in the presence of old Emperor William I. The German Government refused to take the plant and the French Company was facing a serious loss. On account of my knowledge of the German language and past experience, I was entrusted with the difficult task of straightening out matters and early in 1883 I went to Strassburg on that mission.

The First Induction Motor Is Built.

Some of the incidents in that city have left an indelible record on my memory. By a curious coincidence, a number of men who subsequently achieved fame, lived there about that time. In later life I used to say, "There were bacteria of greatness in that old town. Others caught the disease but I escaped!" The practical work, correspondence, and conferences with officials kept me preoccupied day and night, but as soon as I was able to manage I undertook the construction of a simple motor in a mechanical shop opposite the railroad station, having brought with me from Paris some material for that purpose. The consummation of the experiment was, however, delayed until the summer of that year when I finally had the satisfaction of *seeing rotation effected by alternating currents of different phase, and without sliding contacts or commutator*, as I had conceived a year before. It was an exquisite pleasure but not to compare with the delirium of joy following the first revelation.

Among my new friends was the former Mayor of the city, Mr. Bauzin, whom I had already in a measure acquainted with this and other inventions of mine and whose support I endeavored to enlist. He was sincerely devoted to me and put my project before several wealthy persons but, to my mortification, found no response. He wanted to help me in every possible way and the approach of the first of July, 1919, happens to remind me of a form of "assistance" I received from that charming man, which was not financial but none the less appreciated. In 1870, when the Germans invaded the country, Mr. Bauzin had buried a good sized allotment of St. Estèphe of 1801 and he came to the conclusion that he knew no worthier person than myself to consume that precious beverage. This, I may say, is one of the unforgettable incidents to which I have referred. My friend urged me to return to Paris as soon as possible and seek support there. This I was anxious to do but my work and negotiations were protracted owing to all sorts of petty obstacles I encountered so that at times the situation seemed hopeless.

Fig. 2—This Illustrates Tests With Spark Discharges From a Ball of Forty Centimeters Radius in Tesla's Wireless Plant Erected at Colorado Springs in 1899. The Ball Is Connected to the Free End of a Grounded Resonant Circuit Seventeen Meters in Diameter. The Disruptive Potential of a Ball, Is, According to Tesla, in Volts Approximatelly V = 75,400 r (r Being in Centimeters), That Is, in This Case 75,400 x 40 = 3,016,000 Volts. The Gigantic Tesla Coil Which Produced These Bolts of Thor Was Capable of Furnishing a Current of 1,100 Amperes in the High Tension Secondary. The Primary Coil Had a Diameter of 51 Feet! This Tesla Coil Produced Discharges Which Were the Nearest Approach to Lightning Ever Made by Man.

German "Efficiency".

Just to give an idea of German thoroness and "efficiency," I may mention here a rather funny experience. An incandescent lamp of 16 c.p. was to be placed in a hallway and upon selecting the proper location I ordered the *monteur* to run the wires. After working for a while he concluded that the engineer had to be consulted and this was done. The latter made several objections but ultimately agreed that the lamp should be placed two inches from the spot I had assigned, whereupon the work proceeded. Then the engineer became worried and told me that Inspector Averdeck should be notified. That important person called, investigated, debated, and decided that the lamp should be shifted back two inches, which was the place I had marked. It was not long, however, before Averdeck got cold feet himself and advised me that he had informed *Ober-Inspector* Hieronimus of the matter and that I should await his decision. It was several days before the *Ober-Inspector* was able to free himself of other pressing duties but at last he arrived and a two-hour debate followed, when he decided to move the lamp two inches farther. My hopes that this was the final act were shattered when the *Ober-Inspector* returned and said to me: "*Regierungsrath* Funke is so particular that I would not dare to give an order for placing this lamp without his explicit approval." Accordingly arrangements for a visit from that great man were made. We started cleaning up and polishing early in the morning. Everybody brushed up, I put on my gloves and when Funke came with his retinue he was ceremoniously received. After two hours' deliberation he suddenly exclaimed: "I must be going," and pointing to a place on the ceiling, he ordered me to put the

(*Continued on page* 64)

THE proverbial trials and tribulations known to every inventor were not spared Tesla, the world's greatest inventor of all times. In this article we see him, arrived at young manhood, struggling along in a cold world. Already his fame has spread far and wide and his genius is recognized. But converting genius and fame into dollars and cents is quite a different matter, and the world is full of unappreciative and unscrupulous men. Tesla, the idealist, cared little for money and thus was promptly taken advantage of. But let Tesla himself tell you in his own inimitable style. It is a wonderful story.

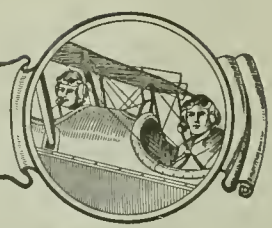
In this month's installment Tesla also tells us how he made one of his most important as well as sensational discoveries—the Tesla Coil. Few inventions have caused such a sensation as this one which culminated in the only man-made lightning ever produced. The Tesla coil has so many uses and has been built in so many styles that it would take a catalog to list them all. From the spectacular high frequency stunts on the stage down to the "violet" ray machine in your home; all are Tesla coils in one form or another.

Wireless without the Tesla Coil would not be possible today. Without an oscillation transformer, spark gap and condenser—which is a Tesla Coil—the sending station would be crippled.

But it is for industrial purposes where the Tesla Coil will shine brightest in the future. The production of Ozone, the extraction of Nitrogen from the air in huge quantities—all are children of Tesla's fertile brain. His coil is the key to them all.

EDITOR.

RADIO DEPARTMENT

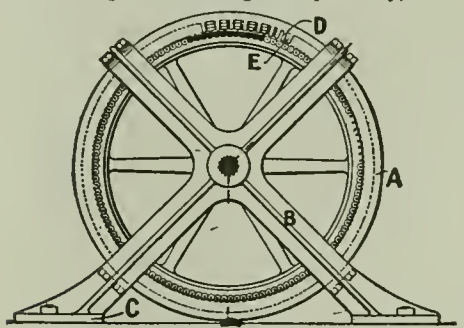


The True Wireless

By NIKOLA TESLA

Written Exclusively for The Electrical Experimenter

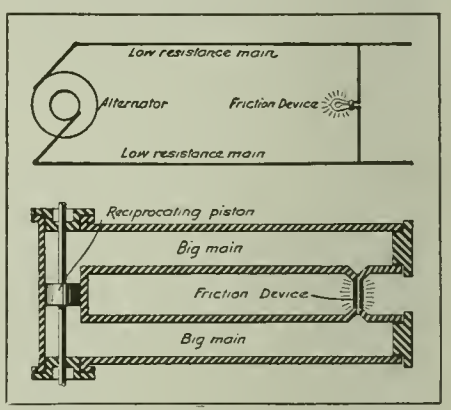
EVER since the announcement of Maxwell's electro-magnetic theory scientific investigators all the world over had been bent on its experimental verification. They were convinced that it would be done and lived in an atmosphere of eager expectancy, unusually favorable to the reception of any evidence to this end. No wonder then that the publication of Dr. Heinrich Hertz's results caused a thrill as had scarcely ever been experienced before. At that time I was in the midst of pressing work in connection with the commercial introduction of my system of power transmission, but, nevertheless, caught the fire of enthusiasm and fairly burned with desire to behold the miracle with my own eyes. Accordingly, as soon as I had freed myself of these imperative duties and resumed research work in my laboratory on Grand Street, New York, I began, parallel with high frequency alternators, the construction of several forms of apparatus with the object of exploring the field opened up by Dr. Hertz. Recognizing the limitations of the devices he had employed, I concentrated my attention on the production of a powerful induction coil but made no notable progress until a happy inspiration led me to the invention of the oscillation transformer. In the latter part of 1891 I was already so far advanced in the development of this new principle that I had at my disposal means vastly superior to those of the German physicist. All my previous efforts with Rhumkorf coils had left me unconvinced, and in order to settle my doubts I went over the whole ground once more, very carefully, with these improved appliances. Similar phenomena were noted, greatly magnified in intensity, but they were susceptible of a different and more plausible explanation. I considered this so important that in 1892 I went to Bonn, Germany, to confer with Dr. Hertz in regard to my observations. He seemed disappointed to such a degree that I regretted my trip and parted from him sorrowfully. During the succeeding years I made numerous experiments with the same object, but the results were uniformly negative. In 1900, however, after I had evolved a wireless transmitter which enabled me to obtain electro-magnetic activities of many millions of horse-power, I made a last desperate attempt to prove that the disturbances emanating from the oscillator were ether vibrations akin to those of light, but met again with utter failure. For more than eighteen years I have been reading treatises, reports of scientific transactions, and articles on Hertz-wave telegraphy, to keep myself informed, but they have always imprest me like works of fiction.



Alternator of 10,000 Cycles p.s., Capacity 10 K.W., Which Was Employed by Tesla in His First Demonstrations of High Frequency Phenomena Before the American Institute of Electrical Engineers at Columbia College, May 20, 1891. Fig. 1.

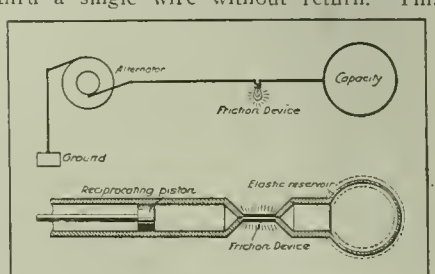
The history of science shows that theories are perishable. With every new truth that is revealed we get a better understanding of Nature and our conceptions and views are modified. Dr. Hertz did not discover a new principle. He merely gave material support to a hypothesis which had been long ago formulated. It was a perfectly well-established fact that a circuit, traversed by a periodic current, emitted some kind of space waves, but we were in ignorance as to their character. He apparently gave an experimental proof that they were transversal vibrations in the ether. Most people look upon this as his great accomplishment. To my mind it seems that his immortal merit was not so much in this as in the focusing of the investigators' attention on the processes taking place in the ambient medium. The Hertz-wave theory, by its fascinating hold on the imagination, has stifled creative effort in the wireless art and retarded it for twenty-five years. But, on the other hand, it is impossible to over-estimate the beneficial effects of the powerful stimulus it has given in many directions.

As regards signaling without wires, the application of these radiations for the purpose was quite obvious. When Dr. Hertz was asked whether such a system would be of practical value, he did not think so, and he was correct in his forecast. The best that might have been expected was a method of communication similar to the heliographic and subject to the same or even greater limitations.



Electric Transmission Thru Two Wires and Hydraulic Analog. Fig. 3.

In the spring of 1891 I gave my demonstrations with a high frequency machine before the American Institute of Electrical Engineers at Columbia College, which laid the foundation to a new and far more promising departure. Altho the laws of electrical resonance were well known at that time and my lamented friend, Dr. John Hopkinson, had even indicated their specific application to an alternator in the Proceedings of the Institute of Electrical Engineers, London, Nov. 13, 1889, nothing had been done towards the practical use of this knowledge and it is probable that those experiments of mine were the first public exhibition with resonant circuits, more particularly of high frequency. While the spontaneous success of my lecture was due to spectacular features, its chief import was in showing that all kinds of devices could be operated thru a single wire without return. This was the initial step in the evolution of my wireless system. The idea presented itself to me that it might be possible, under ob-



Electric Transmission Thru a Single Wire Hydraulic Analog. Fig. 4.

IN this remarkable and complete story of his discovery of the "True Wireless" and the principles upon which transmission and reception, even in the present day systems, are based, Dr. Nikola Tesla shows us that he is indeed the "Father of the Wireless." To him the Hertz wave theory is a delusion; it looks sound from certain angles, but the facts tend to prove that it is hollow and empty. He convinces us that the real Hertz waves are blotted out after they have traveled but a short distance from the sender. It follows, therefore, that the measured antenna current is no indication of the effect, because only a small part of it is effective at a distance. The limited activity of pure Hertz wave transmission and reception is here clearly explained, besides showing definitely that in spite of themselves, the radio engineers of today are employing the original Tesla tuned oscillatory system. He shows by examples with different forms of aërials that the signals picked up by the instruments must actually be induced by earth currents—not etheric space waves. Tesla also disproves the "Heaviside layer" theory from his personal observations and tests.

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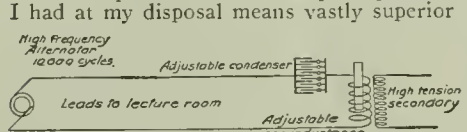
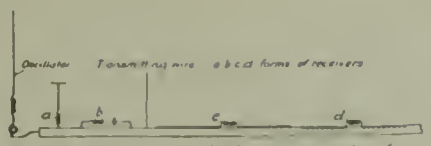


Diagram Illustrating the Circuit Connections and Tuning Devices Employed by Tesla in His Experimental Demonstrations Before the American Institute of Electrical Engineers With the High Frequency Alternator Shown in Fig. 1. Fig. 2.



Illustrating Typical Arrangements for Collecting Energy in a System of Transmission Thru a Single Wire. Fig. 5.

servance of proper conditions of resonance, to transmit electric energy thru the earth, thus dispensing with all artificial conductors. Anyone who might wish to examine impartially the merit of that early suggestion must not view it in the light of present day science. I only need to say that as late as 1893, when I had prepared an elaborate chapter on my wireless system, dwelling on its various instrumentalities and future prospects, Mr. Joseph Wetzler and other friends of mine emphatically protested against its publication on the ground that such idle and far-fetched speculations would injure me in the opinion of conservative business men. So it came that only a small part of what I had intended to say was embodied in my address of that year before the Franklin Institute and National Electric Light Association under the chapter "On Electrical

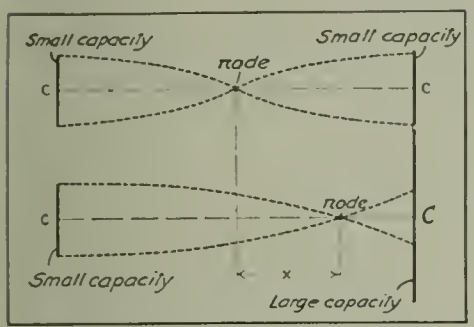
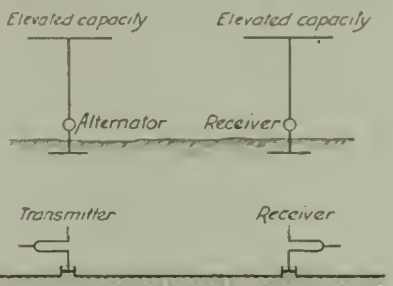


Diagram Elucidating Effect of Large Capacity on One End. Fig. 6.

Resonance." This little salvage from the wreck has earned me the title of "Father of the Wireless" from many well-disposed fellow workers, rather than the invention of scores of appliances which have brought wireless transmission within the reach of every young amateur and which, in a time not distant, will lead to undertakings overshadowing in magnitude and importance all past achievements of the engineer.

The popular impression is that my wireless work was begun in 1893, but as a matter of fact I spent the two preceding years in investigations, employing forms of apparatus, some of which were almost like those of today. It was clear to me from the very start that the successful consummation could only be brought about by a number of radical improvements. Suitable high frequency generators and electrical oscillators had first to be produced. The energy of these had to be transformed in effective transmitters and collected at a distance in proper receivers. Such a system would be manifestly circumscribed in its usefulness if all extraneous interference were not prevented and exclusiveness secured. In time, however, I recognized that devices of this kind, to be most effect-

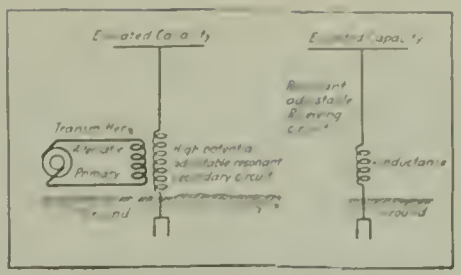


Transmission of Electrical Energy Thru the Earth as Illustrated in Tesla's Lectures Before the Franklin Institute and Electric Light Association in February and March, 1893, and Mechanical Analog of the Same. Fig. 7.

ive and efficient, should be designed with due regard to the physical properties of this planet and the electrical conditions obtaining on the same. I will briefly touch upon the salient advances as they were made in the gradual development of the system.

The high frequency alternator employed in my first demonstrations is illustrated in Fig. 1. It comprised a field ring, with 384 pole projections and a disc armature with coils wound in one single layer which were connected in various ways according to requirements. It was an excellent machine for experimental purposes, furnishing sinusoidal currents of from 10,000 to 20,000 cycles per second. The output was comparatively large, due to the fact that as much as 30 amperes per square millimeter could be past thru the coils without injury.

The diagram in Fig. 2 shows the circuit arrangements as used in my lecture. Resonant conditions were maintained by means

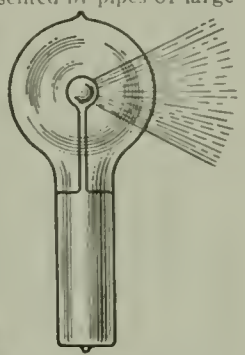


Tesla's System of Wireless Transmission Thru the Earth as Actually Exposed in His Lectures Before the Franklin Institute and Electric Light Association in February and March, 1893. Fig. 8.

of a condenser subdivided into small sections, the finer adjustments being effected by a movable iron core within an inductance coil. Loosely linked with the latter was a high tension secondary which was tuned to the primary.

The operation of devices thru a single wire without return was puzzling at first because of its novelty, but can be readily explained by suitable analogs. For this purpose reference is made to Figs. 3 and 4.

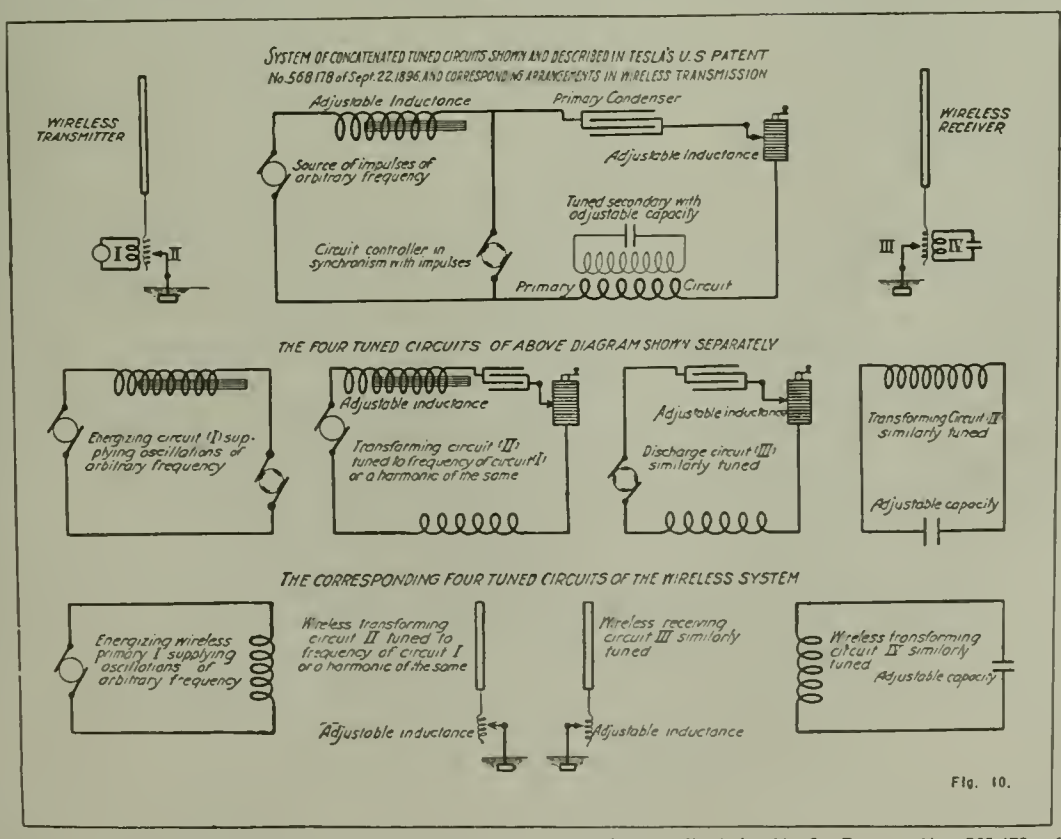
In the former the low resistance electric conductors are represented by pipes of large



The Forerunner of the Audion—the Most Sensitive Wireless Detector Known, as Described by Tesla in His Lecture Before the Institution of Electrical Engineers, London, February, 1892. Fig. 9.

section, the alternator by an oscillating piston and the filament of an incandescent lamp by a minute channel connecting the pipes. It will be clear from a glance at the diagram that very slight excursions of the piston would cause the fluid to rush with high velocity thru the small channel and that virtually all the energy of movement would be transformed into heat by friction, similarly to that of the electric current in the lamp filament.

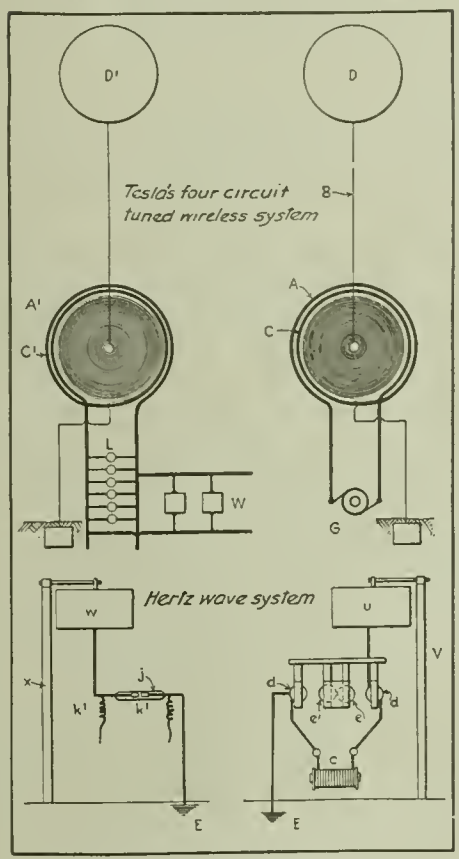
The second diagram will now be self-explanatory. Corresponding to the terminal capacity of the electric system an elastic reservoir is employed which dispenses with the necessity of a return pipe. As the piston oscillates the bag expands and contracts, and the fluid is made to surge thru the restricted passage with great speed, this



Tesla's System of Concatenated Tuned Circuits Shown and Described in U. S. Patent No. 568,178 of September 22, 1896, and Corresponding Arrangements in Wireless Transmission.

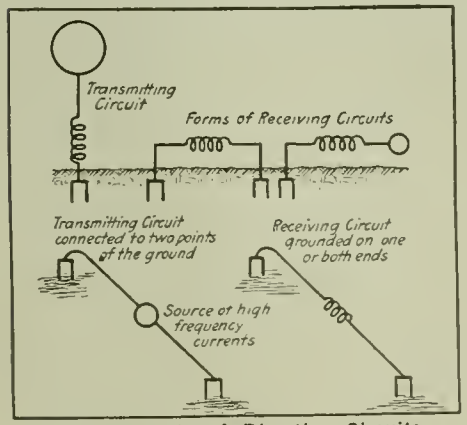
resulting in the generation of heat as in the incandescent lamp. Theoretically considered, the efficiency of conversion of energy should be the same in both cases.

Granted, then, that an economic system of power transmission thru a single wire is



Tesla's Four Circuit Tuned System Contrasted With the Contemporaneous Hertz-wave System. Fig. 11.

practicable, the question arises how to collect the energy in the receivers. With this object attention is called to Fig. 5, in which a conductor is shown excited by an oscillator joined to it at one end. Evidently, as the periodic impulses pass thru the wire, differences of potential will be created along the same as well as at right angles to it in the surrounding medium and either of these may be usefully applied. Thus at *a*, a circuit comprising an inductance and capacity is resonantly excited in the transverse, and at *b*, in the longitudinal sense. At *c*, energy is collected in a circuit parallel to the conductor but not in contact with it, and again at *d*, in a circuit which is partly sunk into the conductor and may be, or not, electrically connected to the same. It is important to keep these typical dispositions in mind, for however the distant ac-



Arrangements of Directive Circuits Described in Tesla's U. S. Patent No. 613,809 of November 8, 1898, on "Method of and Apparatus for Controlling Mechanism of Moving Vessels or Vehicles." Fig. 12.

tions of the oscillator might be modified thru the immense extent of the globe the principles involved are the same.

Consider now the effect of such a conductor of vast dimensions on a circuit exciting it. The upper diagram of Fig. 6 illustrates a familiar oscillating system comprising a straight rod of self-inductance $2L$ with small terminal capacities cc and a node in the center. In the lower diagram of the figure a large capacity C is attached to the rod at one end with the result of shifting the node to the right, thru a distance corresponding to self-inductance X. As both parts of the system on either side of the node vibrate at the same rate, we have evidently, $(L + X)\ c = (L - X)\ C$ from which $X = L\ \frac{C - c}{C + c}$. When the capacity C becomes commensurate to that of the earth, X approximates L, in other words, the node is close to the ground connection. *The exact determination of its position is very important in the calculation of certain terrestrial electrical and geodetic data* and I have devised special means with this purpose in view.

My original plan of transmitting energy without wires is shown in the upper diagram of Fig. 7, while the lower one illustrates its mechanical analog, first publisht in my article in the *Century Magazine* of June, 1900. An alternator, preferably of high tension, has one of its terminals connected to the ground and the other to an elevated capacity and impresses its oscillations upon the earth. At a distant point a receiving circuit, likewise connected to ground and to an elevated capacity, collects some of the energy and actuates a suitable device. I suggested a multiplication of such units in order to intensify the effects, an idea which may yet prove valuable. In the analog two tuning forks are provided, one at the sending and the other at the receiving station, each having attached to its lower prong a piston fitting in a cylinder. The two cylinders communicate with a large elastic reservoir filled with an incom-

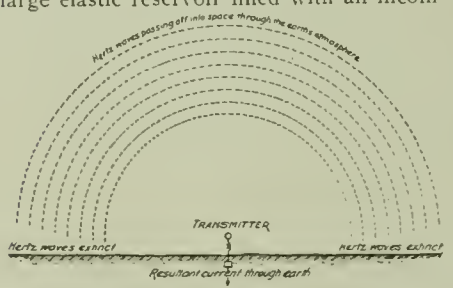


Diagram Exposing the Fallacy of the Gliding Wave Theory as Propounded in Wireless Text Books. Fig. 13.

pressible fluid. The vibrations transmitted to either of the tuning forks excite them by resonance and, thru electrical contacts or otherwise, bring about the desired result. This, I may say, was not a mere mechanical illustration, but a simple representation of my apparatus for submarine signaling, perfected by me in 1892, but not appreciated at that time, altho more efficient than the instruments now in use.

The electric diagram in Fig. 7, which was reproduced from my lecture, was meant only for the exposition of the principle. The arrangement, as I described it in detail, is shown in Fig. 8. In this case an alternator energizes the primary of a transformer, the high tension secondary of which is connected to the ground and an elevated capacity and tuned to the imprest oscillations. The receiving circuit consists of an inductance connected to the ground and to an elevated terminal without break and is resonantly responsive to the transmitted oscillations. A specific form of receiving device was not mentioned, but I had in mind to transform the received currents and thus make their volume and tension suitable for any purpose. This, in substance, is the system of today and I am not aware of a single authenticated instance of successful transmission at considerable distance by different instrumentalities. It might, perhaps, not be clear to

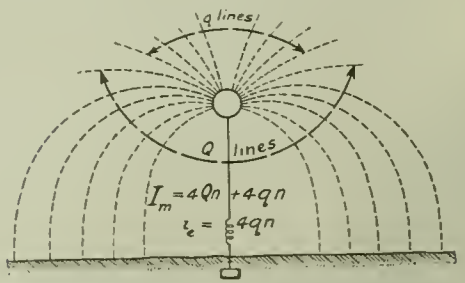


Fig. 14. Diagram Explaining the Relation Between the Effective and the Measured Current in the Antenna.

those who have perused my first description of these improvements that, besides making known new and efficient types of apparatus, I gave to the world a wireless system of potentialities far beyond anything before conceived. I made explicit

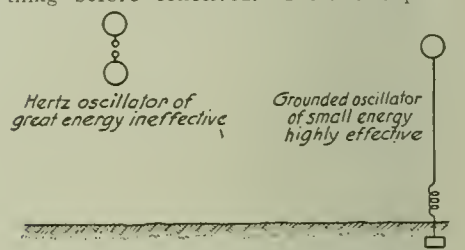


Fig. 15. Illustrating One of the General Evidences Against the Space Wave Transmission.

and repeated statements that I contemplated transmission, absolutely unlimited as to terrestrial distance and amount of energy. But, altho I have overcome all obstacles which seemed in the beginning unsurmountable and found elegant solutions of all the problems which confronted me, yet, even at this very day, the majority of experts are still blind to the possibilities which are within easy attainment.

My confidence that a signal could be easily flashed around the globe was strengthened thru the discovery of the "rotating brush," a wonderful phenomenon which I have fully described in my address before the Institution of Electrical Engineers, London, in 1892, and which is illustrated in Fig. 9. This is undoubtedly the most delicate wireless detector known, but for a long time it was hard to produce and to maintain in the sensitive state. These difficulties do not exist now and I am looking to valuable applications of this device, particularly in connection with the high-speed photographic method, which I suggested, in wireless, as well as in wire, transmission.

Possibly the most important advances during the following three or four years were my system of concatenated tuned circuits

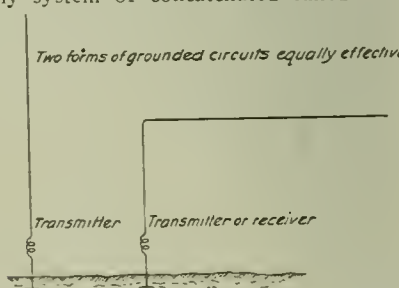


Fig. 16. Showing Unimportance of Relative Position of Transmitting and Receiving Antennae in Disproval of the Hertz-wave Theory.

and methods of regulation, now universally adopted. The intimate bearing of these inventions on the development of the wireless art will appear from Fig. 10, which illus-

(*Continued on page* 61)

The True Wireless

By Nikola Tesla

(Continued from page 30)

trates an arrangement described in my U. S. Patent No. 568178 of September 22, 1896, and corresponding dispositions of wireless apparatus. The captions of the individual diagrams are thought sufficiently explicit to dispense with further comment. I will merely remark that in this early record, in addition to indicating how any number of resonant circuits may be linked and regulated, I have shown the advantage of the proper timing of primary impulses and use of harmonics. In a farcical wireless suit in London, some engineers, reckless of their reputation, have claimed that my circuits were not at all attuned; in fact they asserted that I had looked upon resonance as a sort of wild and untamable beast!

It will be of interest to compare my system as first described in a Belgian patent of 1897 with the Hertz-wave system of that period. The significant differences between them will be observed at a glance. The first enables us to transmit economically energy to any distance and is of inestimable value; the latter is capable of a radius of only a few miles and is worthless. In the first there are no spark-gaps and the actions are enormously magnified by resonance. In both transmitter and receiver the currents are transformed and rendered more effective and suitable for the operation of any desired device. Properly constructed, my system is safe against static and other interference and the amount of energy which may be transmitted is *billions of times greater* than with the Hertzian which has none of these virtues, has never been used successfully and of which no trace can be found at present.

A well-advertised expert gave out a statement in 1899 that my apparatus did not work and that it would take 200 years before a message would be flashed across the Atlantic and he even accepted stolidly my congratulations on a supposed great feat. But subsequent examination of the records showed that my devices were secretly used all the time and ever since I learned of this I have treated these Borgia-Medici methods with the contempt in which they are held by all fair-minded men. The wholesale appropriation of my inventions was, however, not always without a diverting side. As an example to the point I may mention my oscillation transformer operating with an air gap. This was in turn replaced by a carbon arc, quenched gap, an atmosphere of hydrogen, argon or helium, by a mechanical break with oppositely rotating members, a mercury interrupter or some kind of a vacuum bulb and by such *tours de force* as many new "systems" have been produced. I refer to this of course, without the slightest ill-feeling, let us advance by all means. But I cannot help thinking how much better it would have been if the ingenious men, who have originated these "systems," had invented something of their own instead of depending on me altogether.

Before 1900 two most valuable improvements were made. One of these was my individualized system with transmitters emitting a wave-complex and receivers comprising separate tuned elements coöperatively associated. The underlying principle can be explained in a few words. Suppose that there are n simple vibrations suitable for use in wireless transmission, the probability that any one tune will be struck by an extraneous disturbance is $\frac{1}{n}$. There will then remain $n-1$ vibrations and the chance that one of these will be excited is $\frac{1}{n-1}$, hence the probability that two tunes would

be struck at the same time is $\frac{1}{n\,(n-1)}$. Similarly, for a combination of three the chance will be $\frac{1}{n\,(n-1)\,(n-2)}$ and so on. It will be readily seen that in this manner any desired degree of safety against the statics or other kind of disturbance can be attained provided the receiving apparatus is so designed that its operation is possible only thru the joint action of all the tuned elements. This was a difficult problem which I have successfully solved so that now *any desired number of simultaneous messages is practicable in the transmission thru the earth as well as thru artificial conductors.*

The other invention, of still greater importance, is a peculiar oscillator enabling the transmission of energy without wires in any quantity that may ever be required for industrial use, to any distance, and with very high economy. It was the outcome of years of systematic study and investigation and wonders will be achieved by its means.

The prevailing misconception of the mechanism involved in the wireless transmission has been responsible for various unwarranted announcements which have misled the public and worked harm. By keeping steadily in mind that the transmission thru the earth is in every respect identical to that thru a straight wire, one will gain a clear understanding of the phenomena and will be able to judge correctly the merits of a new scheme. Without wishing to detract from the value of any plan that has been put forward I may say that they are devoid of novelty. So for instance in Fig. 12 arrangements of transmitting and receiving circuits are illustrated, which I have described in my U. S. Patent No. 613809 of November 8, 1898 on a Method of and Apparatus for Controlling Mechanism of Moving Vessels or Vehicles, and which have been recently dished up as original discoveries. In other patents and technical publications I have suggested conductors in the ground as one of the obvious modifications indicated in Fig. 5.

For the same reason the statics are still the bane of the wireless. There is about as much virtue in the remedies recently proposed as in hair restorers. *A small and compact apparatus has been produced which does away entirely with this trouble,* at least in plants suitably remodelled.

Nothing is more important in the present phase of development of the wireless art than to dispose of the dominating erroneous ideas. With this object I shall advance a few arguments based on my own observations *which prove that Hertz waves have little to do with the results obtained even at small distances.*

In Fig. 13 a transmitter is shown radiating space waves of considerable frequency. It is generally believed that these waves pass along the earth's surface and thus affect the receivers. I can hardly think of anything more improbable than this "gliding wave" theory and the conception of the "guided wireless" which are contrary to all laws of action and reaction. Why should these disturbances cling to a conductor where they are counteracted by induced currents, when they can propagate in all other directions unimpeded? The fact is that the radiations of the transmitter passing along the earth's surface are soon extinguished, the height of the inactive zone indicated in the diagram, being some function of the wave length, the bulk of the waves traversing freely the atmosphere. Terrestrial phenomena which I have noted conclusively show that there is no *Heaviside layer,* or if it exists, it is of no effect. It certainly would be unfortunate if the human race were thus imprisoned and forever without power to reach out into the depths of space.

The actions at a distance cannot be proportionate to the height of the antenna and the current in the same. I shall endeavor to make this clear by reference to diagram in Fig. 14. The elevated terminal charged to a high potential induces an equal and opposite charge in the earth and there are thus Q lines giving an average current $I = 4Qn$ which circulates locally and is useless except that it adds to the momentum. A relatively small number of lines q however, go off to great distance and to these corresponds a mean current of $i_e = 4qn$ *to which is due the action at a distance.* The total average current in the antenna is thus $I_m = 4Qn + 4qn$ and its intensity is no criterion for the performance. The electric efficiency of the antenna is $\frac{q}{Q+q}$ and this is often a very small fraction.

Dr. L. W. Austin and Mr. J. L. Hogan have made quantitative measurements which are valuable, but far from supporting the Hertz wave theory they are evidences in disproval of the same, as will be easily perceived by taking the above facts into consideration. Dr. Austin's researches are especially useful and instructive and I regret that I cannot agree with him on this subject. I do not think that if his receiver was affected by Hertz waves he could ever establish such relations as he has found, but he would be likely to reach these results if the Hertz waves were in a large part eliminated. At great distance the space waves and the current waves are of equal energy, the former being merely an accompanying manifestation of the latter in accordance with the fundamental teachings of Maxwell.

It occurs to me here to ask the question—why have the Hertz waves been reduced from the original frequencies to those I have advocated for my system, when in so doing the activity of the transmitting apparatus has been reduced a billion fold? I can invite any expert to perform an experiment such as is illustrated in Fig. 15, which shows the classical Hertz oscillator and my grounded transmitting circuit. It is a fact which I have demonstrated that, altho we may have in the Hertz oscillator an activity thousands of times greater, the effect on the receiver is not to be compared to that of the grounded circuit. This shows that *in the transmission from an airplane we are merely working thru a condenser,* the capacity of which is a function of a logarithmic ratio between the length of the conductor and the distance from the ground. The receiver is affected in exactly the same manner as from an ordinary transmitter, the only difference being that there is a certain modification of the action which can be predetermined from the electrical constants. It is not at all difficult to maintain communication between an airplane and a station on the ground, on the contrary, the feat is very easy.

To mention another experiment in support of my view, I may refer to Fig. 16 in which two grounded circuits are shown excited by oscillations of the Hertzian order. It will be found that the antennas can be put out of parallelism without noticeable change in the action on the receiver, this proving that it is due to currents propagated thru the ground and not to space waves.

Particularly significant are the results obtained in cases illustrated in Figures 17 and 18. In the former an obstacle is shown in the path of the waves but unless the receiver is within the effective *electrostatic* influence of the mountain range, the signals are not appreciably weakened by the presence of the latter, because the currents pass under it and excite the circuit in the same way as if it were attached to an energized wire. If, as in Fig. 18, a second range happens to be beyond the receiver, it could only strengthen the Hertz wave effect by reflection, but as a matter of fact it detracts

(*Continued on page 87*)

My Inventions

(Continued from page 17)

lamp there. It was the exact spot which I had originally chosen.

So it went day after day with variations, but I was determined to achieve at whatever cost and in the end my efforts were rewarded. By the spring of 1884 all the differences were adjusted, the plant formally accepted, and I returned to Paris with pleasing anticipations. One of the administrators had promised me a liberal compensation in case I succeeded, as well as a fair consideration of the improvements I had made in their dynamos and I hoped to realize a substantial sum. There were three administrators whom I shall designate as A, B and C for convenience. When I called on A *he* told me that B had the say. This gentleman thought that only C could decide and the latter was quite sure that A alone had the power to act. After several laps of this *circulus viciosus*, it dawned upon me that my reward was a castle in Spain. The utter failure of my attempts to raise capital for development was another disappointment and when Mr. Batchellor prest me to go to America with a view of redesigning the Edison machines, I determined to try my fortunes in the Land of Golden Promise. But the chance was nearly mist. I liquefied my modest assets, secured accommodations and found myself at the railroad station as the train was pulling out. At that moment I discovered that my money and tickets were gone. What to do was the question. Hercules had plenty of time to deliberate but I had to decide while running alongside the train with opposite feelings surging in my brain like condenser oscillations. Resolve, helped by dexterity, won out in the nick of time and upon passing thru the usual experiences, as trivial as unpleasant, I managed to embark for New York with the remnants of my belongings, some poems and articles I had written, and a package of calculations relating to solutions of an unsolvable integral and to my flying machine. During the voyage I sat most of the time at the stern of the ship watching for an opportunity to save somebody from a watery grave, without the slightest thought of danger. Later when I had absorbed some of the practical American sense I shivered at the recollection and marvelled at my former folly.

Tesla in America

I wish that I could put in words my first impressions of this country In the Arabian Tales I read how genii transported people into a land of dreams to live thru delightful adventures. My case was just the reverse. The genii had carried me from a world of dreams into one of realities. What I had left was beautiful, artistic and fascinating in every way; what I saw here was machined, rough and unattractive. A burly policeman was twirling his stick which looked to me as big as a log. I approached him politely with the request to direct me. "Six blocks down, then to the left," he said, with murder in his eyes. "Is this America?" I asked myself in painful surprise. "It is a century behind Europe in civilization." When I went abroad in 1889—five years having elapsed since my arrival here—I became convinced that *it was more than one hundred years AHEAD of Europe* and nothing has happened to this day to change my opinion.

Tesla Meets Edison

The meeting with Edison was a memorable event in my life. I was amazed at this wonderful man who, without early advantages and scientific training, had accomplished so much. I had studied a dozen languages, delved in literature and art, and had spent my best years in libraries reading all sorts of stuff that fell into my hands, from Newton's *"Principia"* to the novels of Paul de Kock, and felt that most of my life had been squandered. But it did not take long before I recognized that it was the best thing I could have done. Within a few weeks I had won Edison's confidence and it came about in this way.

The S. S. *Oregon*, the fastest passenger steamer at that time, had both of its lighting machines disabled and its sailing was delayed. As the superstructure had been built after their installation it was impossible to remove them from the hold. The predicament was a serious one and Edison was much annoyed. In the evening I took the necessary instruments with me and went aboard the vessel where I stayed for the night. The dynamos were in bad condition, having several short-circuits and breaks, but with the assistance of the crew I succeeded in putting them in good shape. At five o'clock in the morning, when passing along Fifth Avenue on my way to the shop, I met Edison with Batchellor and a few others as they were returning home to retire. "Here is our Parisian running around at night," he said. When I told him that I was coming from the *Oregon* and had repaired both machines, he looked at me in silence and walked away without another word. But when he had gone some distance I heard him remark: "Batchellor, this is a d—n good man," and from that time on I had full freedom in directing the work. For nearly a year my regular hours were from 10.30 A. M. until 5 o'clock the next

morning without a day's exception. Edison said to me: "I have had many hard-working assistants but you take the cake." During this period I designed twenty-four different types of standard machines with short cores and of uniform pattern which replaced the old ones. The Manager had promised me fifty thousand dollars on the completion of this task but it turned out to be a practical joke. This gave me a painful shock and I resigned my position.

Immediately thereafter some people approached me with the proposal of forming an arc light company under my name, to which I agreed. Here finally was an opportunity to develop the motor, but when I broached the subject to my new associates they said: "No, we want the arc lamp. We don't care for this alternating current of yours." In 1886 my system of arc lighting was perfected and adopted for factory and municipal lighting, and I was free, but with no other possession than a beautifully engraved certificate of stock of hypothetical value. Then followed a period of struggle in the new medium for which I was not fitted, but the reward came in the end and in April, 1887, the Tesla Electric Company was organized, providing a laboratory and facilities. The motors I built there were exactly as I had imagined them. I made no attempt to improve the design, but merely reproduced the pictures as they appeared to my vision and the operation was always as I expected.

In the early part of 1888 an arrangement was made with the Westinghouse Company for the manufacture of the motors on a large scale. But great difficulties had still to be overcome. My system was based on the use of low frequency currents and the Westinghouse experts had adopted 133 cycles with the object of securing advantages in the transformation. They did not want to depart from their standard forms of apparatus and my efforts had to be concentrated upon adapting the motor to these conditions. Another necessity was to produce a motor capable of running efficiently at this frequency on two wires which was not easy of accomplishment.

At the close of 1889, however, my services in Pittsburg being no longer essential, I returned to New York and resumed experimental work in a laboratory on Grand Street, where I began immediately the design of high frequency machines. The problems of construction in this unexplored field were novel and quite peculiar and I encountered many difficulties. I rejected the inductor type, fearing that it might not yield perfect sine waves which were so important to resonant action. Had it not been for this I could have saved myself a great deal of labor. Another discouraging feature of the high frequency alternator seemed to be the inconstancy of speed which threatened to impose serious limitations to its use. I had already noted in my demonstrations before the American Institution of Electrical Engineers that several times the tune was lost, necessitating readjustment, and did not yet foresee, what I discovered long afterwards, a means of operating a machine of this kind at a speed constant to such a degree as not to vary more than a small fraction of one revolution between the extremes of load.

The Invention of the Tesla Coil

From many other considerations it appeared desirable to invent a simpler device for the production of electric oscillations. In 1856 Lord Kelvin had exposed the theory of the condenser discharge, but no practical application of that important knowledge was made. I saw the possibilities and undertook the development of induction apparatus on this principle. My progress was so rapid as to enable me to exhibit at my lecture in 1891 a coil giving sparks of *five inches*. On that occasion I frankly told the

(*Continued on page* 89)

The True Wireless

By Nikola Tesla

(Continued from page 63)

greatly from the intensity of the received impulses because the electric niveau between the mountains is raised, as I have explained in connection with my lightning protector in the EXPERIMENTER of February.

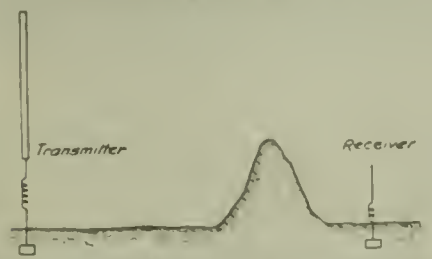


Fig. 17. Illustrating Influence of Obstacle in the Path of Transmission as Evidence Against the Hertz-wave Theory.

Again in Fig. 19 two transmitting circuits, one grounded directly and the other thru an air gap, are shown. It is a common observation that the former is far

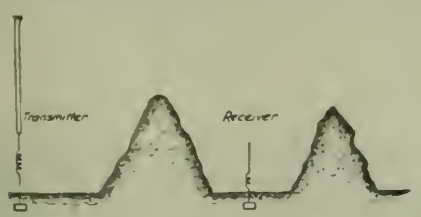


Fig. 18. Showing Effect of Two Hills as Further Proof Against the Hertz-wave Theory.

more effective, which could not be the case in a transmission with Hertz radiations. In like manner if two grounded circuits are

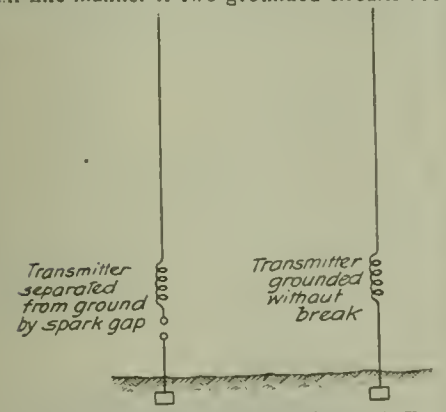


Fig. 19. Comparing the Actions of Two Forms of Transmitter as Bearing Out the Fallacy of the Hertz-wave Theory.

observed from day to day the effect is found to increase greatly with the dampness of the ground, and for the same reason

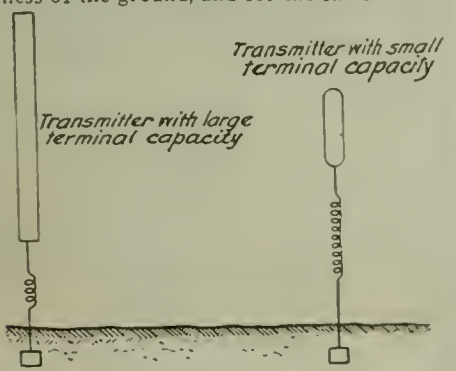


Fig. 20. Disproving the Hertz-wave Theory by Two Transmitters, One of Great and the Other of Small Energy.

also the transmission thru sea-water is more efficient.

An illuminating experiment is indicated in Fig. 20 in which two grounded transmitters are shown, one with a large and the other with a small terminal capacity. Suppose that the latter be 1/10 of the former but that it is charged to 10 times the potential and let the frequency of the two circuits and therefore the currents in both antennas be exactly the same. The circuit with the smaller capacity will then have 10 times the energy of the other but the effects on the receiver will be in no wise proportionate.

The same conclusions will be reached by transmitting and receiving circuits with wires buried underground. In each case the actions carefully investigated will be found to be due to *earth currents*. Numerous other proofs might be cited which can be easily verified. So for example *oscillations of low frequency* are ever so much more effective in the transmission which is inconsistent with the prevailing idea. My observations in 1900 and the recent transmissions of signals to very great distances are another emphatic disproval.

The Hertz wave theory of wireless transmission may be kept up for a while, but I do not hesitate to say that in a short time it will be recognized as one of the most remarkable and inexplicable aberrations of the scientific mind which has ever been recorded in history.

TO ALL RADIO AMATEURS

We have received many thousands of communications from radio amateurs for the past few months asking us about the status of their radio stations, and when they will be allowed to operate them again.

Inasmuch as there has been no official information as to the reopening of amateur stations, during the armistice, we can only say that in all likelihood, amateurs will not be allowed to operate until actual peace has been signed. In his executive order of April the 6th, 1917, President Wilson closed all radio stations in the United States by an act approved in the Radio Law of August 13, 1912.

Such a measure, according to law, is only for the duration of the war, there being at present no legislation which prevents any station, amateur or otherwise, from operating after peace has actually been declared. Therefore, the minute newspapers announce that peace between the United States and the Central Powers has been signed, *all amateur stations automatically revert to their former status*, and amateurs need not wait for permission to operate their stations, once peace has been declared.

EDITOR.

WRINKLES, RECIPES & FORMULAS.

(Continued from page 42)

If carbon dioxid is to be generated, fill tube A with marble chips and tube B with dilute hydrochloric acid.

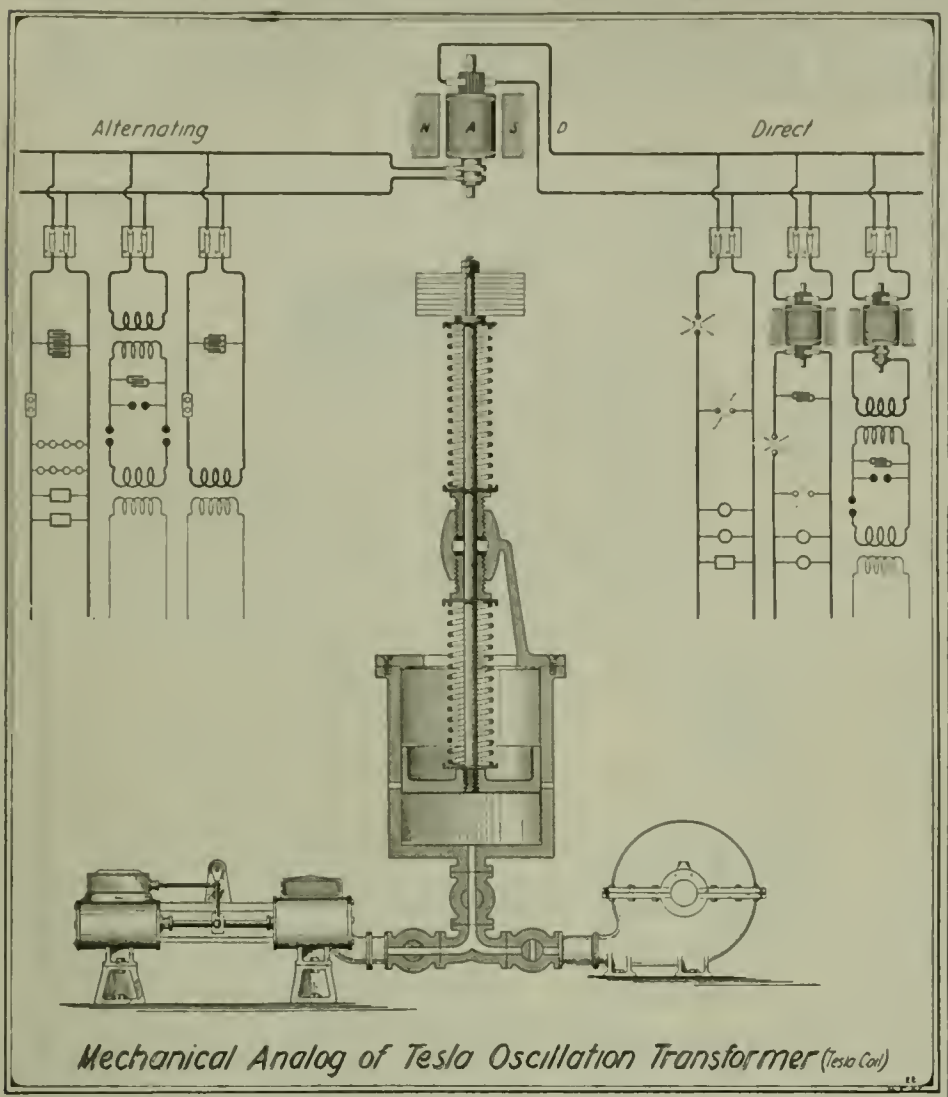
It is evident that the parts of the generator can be easily cleaned and new chemicals put in. The completed apparatus is shown in Fig. 3.

Contributed by S. WEISINGER, JR.

My Inventions

(*Continued from page 65*)

engineers of a defect involved in the transformation by the new method, namely, the loss in the spark gap. Subsequent investigation showed that no matter what medium is employed, be it air, hydrogen, mercury vapor, oil or a stream of electrons, the efficiency is the same. It is a law very much like that governing the conversion of mechanical energy. We may drop a weight from a certain height vertically down or carry it to the lower level along any devious path, it is immaterial insofar as the amount of work is concerned. Fortunately however, this drawback is not fatal as by proper proportioning of the resonant circuits an *efficiency of* 85 *per cent* is attainable. Since my early announcement of the invention it has come into universal use and wrought a revolution in many departments. But a still greater future awaits it. When in 1900 I obtained powerful discharges of 100 feet and flashed a current around the globe, I was reminded of the first tiny spark I observed in my Grand Street laboratory and was thrilled by sensations akin to those I felt when I discovered the *rotating magnetic field*.



Mechanical Analog of Tesla Oscillation Transformer (Tesla Coil)

This revolutionary improvement was exhibited and explained by Tesla for the first time in his lecture before the American Institute of Electrical Engineers May 20, 1891. It has made possible to generate automatically damped or undamped oscillations of any desired frequency and, what is equally important, of perfectly constant period. It has been instrumental in many great achievements and its use has become universal. The underlying principle may be briefly stated as follows: A source of electricity is made to charge a condenser and when the difference of potential at the terminals of the latter has reached a predetermined value, an air-gap is bridged, permitting the accumulated energy to be discharged through a circuit under resonant conditions, this resulting in a long series of isochronous impulses. These are either directly used or converted to any desired volume or pressure by means of a second circuit inductively linked with the first and tuned to the same. The above diagram is taken from Tesla's lecture before the Franklin Institute and National Electric Light Association in 1893 and shows more elaborate arrangements of circuits, now quite familiar, for the conversion of ordinary direct or alternating currents into high frequency oscillations by this general method. In the mechanical apparatus illustrated, an attempt is made to convey an idea of the electrical operations as closely as practicable. The reciprocating and centrifugal pumps, respectively, represent an alternating and a direct current generator. The water takes the place of the electric fluid. The cylinder with its elastically restrained piston represents the condenser. The inertia of the moving parts corresponds to the self-induction of the electric circuit and the wide ports around the cylinder, through which the fluid can escape, perform the function of the air-gap. The operation of this apparatus will now be readily understood. Suppose first that the water is admitted to the cylinder from the centrifugal pump, this corresponding to the action of a continuous current generator. As the fluid is forced into the cylinder, the piston moves upward until the ports are uncovered, when a great quantity of the fluid rushes out, suddenly reducing the pressure so that the force of the compressed spring asserts itself and sends the piston down, closing the ports, whereupon these operations are repeated in as rapid succession as it may be desired. Each time the system, comprising the piston, rod, weights and adjustable spring, receives a blow, it quivers at its own rate which is determined by the inertia of the moving parts and the pliability of the spring exactly as in the electrical system the period of the circuit is determined by the self-induction and capacity. Under the best conditions the natural period of the elastic system will be the same as that of the primarily impressed oscillations, and then the energy of the movement will be greatest. If, instead of the centrifugal, the reciprocating pump is employed, the operation is the same in principle except that the periodic impulses of the pump impose certain limitations. The best results are again obtained when synchronism is maintained between these and the natural oscillations of the system.

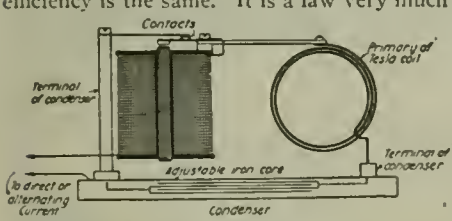


Fig. 3—Scheme of Circuit Connections in Tesla's Oscillation Transformer Shown in Fig. 1. The Secondary Circuit Which Slips Into the Primary Is Omitted.

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EDITORIAL

Tree Wireless

IN 1904, during Army maneuvers in California, General, then Major, George O. Squier, of the U. S. Signal Corps, made the important discovery that it was possible to receive radio messages, using live trees as an aërial. He found that by merely driving a metallic spike into the tree trunk, a few feet above the ground, and by connecting the wire from his radio receiving instruments to the spike, messages would come in astonishingly well over this new "aërial".

The invention, while important, received but scant notice, even in the scientific press of that day. Indeed, the majority of radio people knew very little about the invention, and those who did know considered the tree aërial as a freak, along with the bed-spring aërial and others of a similar nature.

During the war, however, the discoverer of the system, who had now become Major General Squier, Chief Signal Officer of the Army, made many new experiments with trees and radio. Recently, before the Physical Society, General Squier delivered a highly interesting lecture on the subject, and from what transpired, it is certain we have merely scratched the surface of an important invention.

General Squier, for instance, has been in constant communication with Europe for months, receiving messages from all of the large radio stations located in England, France, Italy and Germany, using nothing but trees for his aërials. But that was not all. He demonstrated that it was just as easy to *send* radio messages over a tree as it was to receive them. Indeed this holds true not only for telegraph messages, but radio telephone communication has been actually carried on between trees over a distance of *three miles!* So far no attempt has been made to increase this distance, altho it is obvious that any distance, depending only upon the power of the sending instruments, can be bridged in this manner.

That this system proved of immense value during the war can be readily imagined. Our signal corps men for that reason never were troubled with the communication lines in their rear, as long as there was a live tree about. No conspicuous wire aërial was needed for their radio work; code messages flew back and forth from the most extended points of our lines, right under the Germans' noses, who never suspected innocent-looking trees as being the carriers of priceless information.

General Squier thinks that the tree aërial will soon supplant the wire antenna entirely; even the big commercial stations, he thinks, can make excellent use of his discovery. The radio amateur particularly, will find the trees about his house a new and welcome source for his experiments. Many parents and landlords object to unsightly aërials on or about the house. An innocent-looking tree—if there is one near at hand—now solves the problem for the ambitious amateur. And the higher the tree, the better the results.

The new botanical antenna, on the other hand, brings us many new and interesting problems. One—and a curious one at that—is: How to figure the *wave length* of such an aërial! No doubt General Squier has, or will work out a standard formula for us. Undoubtedly, too, the wave length will vary from year to year—due to the growth of the tree. Then, too, in Spring, before the leaves are on the tree, the wave-length should be slightly less than in the summer time, due to the smaller area and resultant capacity. Also it would seem that in the winter time, the wave-length of the tree would be much less than in the Spring, due to the conducting sap receding from the branches.

Suppose you were to "spike up" every tree in a small wood—say, a thousand trees! The enormous area exposed to the ether, would theoretically give us a wonderfully effective antenna. We say theoretically, because we do not know how the immense added capacity would affect our instruments.

H. GERNSBACK.

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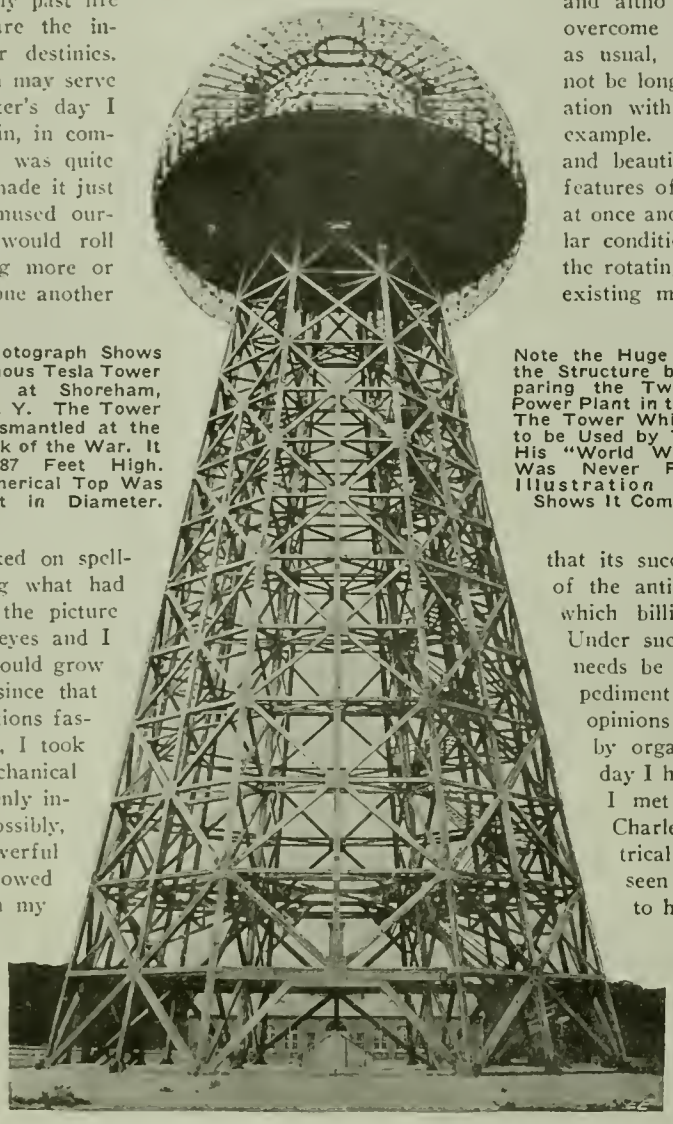
My Inventions

By Nikola Tesla

V. The Magnifying Transmitter

AS I review the events of my past life I realize how subtle are the influences that shape our destinies. An incident of my youth may serve to illustrate. One winter's day I managed to climb a steep mountain, in company with other boys. The snow was quite deep and a warm southerly wind made it just suitable for our purpose. We amused ourselves by throwing balls which would roll down a certain distance, gathering more or less snow, and we tried to outdo one another in this exciting sport. Suddenly a ball was seen to go beyond the limit, swelling to enormous proportions until it became as big as a house and plunged thundering into the valley below with a force that made the ground tremble. I looked on spellbound, incapable of understanding what had happened. For weeks afterward the picture of the avalanche was before my eyes and I wondered how anything so small could grow to such an immense size. Ever since that time the magnification of feeble actions fascinated me, and when, years later, I took up the experimental study of mechanical and electrical resonance, I was keenly interested from the very start. Possibly, had it not been for that early powerful impression, I might not have followed up the little spark I obtained with my coil and never developed my best invention, the true history of which I will tell here for the first time.



This Photograph Shows the Famous Tesla Tower Erected at Shoreham, L. I., N. Y. The Tower Was Dismantled at the Outbreak of the War. It Was 187 Feet High. The Spherical Top Was 68 Feet in Diameter.

Note the Huge Size of the Structure by Comparing the Two-story Power Plant in the Rear. The Tower Which Was to be Used by Tesla in His "World Wireless," Was Never Finished. Illustration Opposite Shows It Completed.

Scrapping the World's Engines.

"Lionhunters" have often asked me which of my discoveries I prize most. This depends on the point of view. Not a few technical men, very able in their special departments, but dominated by a pedantic spirit and near-sighted, have asserted that excepting the induction motor I have given to the world little of practical use. This is a grievous mistake. A new idea must not be judged by its immediate results. My alternating system of power transmission came at a psychological moment, as a long-sought answer to pressing industrial questions, and altho considerable resistance had to be overcome and opposing interests reconciled, as usual, the commercial introduction could not be long delayed. Now, compare this situation with that confronting my turbine, for example. One should think that so simple and beautiful an invention, possessing many features of an ideal motor, should be adopted at once and, undoubtedly, it would under similar conditions. But the prospective effect of the rotating field was not to render worthless existing machinery; on the contrary, it was to give it additional value. The system lent itself to new enterprise as well as to improvement of the old. My turbine is an advance of a character entirely different. It is a radical departure in the sense that its success would mean the abandonment of the antiquated types of prime movers on which billions of dollars have been spent. Under such circumstances the progress must needs be slow and perhaps the greatest impediment is encountered in the prejudicial opinions created in the minds of experts by organized opposition. Only the other day I had a disheartening experience when I met my friend and former assistant, Charles F. Scott, now professor of Electrical Engineering at Yale. I had not seen him for a long time and was glad to have an opportunity for a little chat at my office. Our conversation naturally enough drifted on my turbine and I became heated to a high degree. "Scott," I exclaimed, carried away by the vision of a glorious future, "my turbine will scrap all the heat-engines in the world." Scott stroked his chin and looked away thoughtfully, as though making a mental calculation. "That will make quite a pile of scrap," he said, and left without another word!

IMAGINE a man a century ago, bold enough to design and actually build a huge tower with which to transmit the human voice, music, pictures, press news and even power, thru the earth to any distance whatever without wires! He probably would have been hung or burnt at the stake. So when Tesla built his famous tower on Long Island he was a hundred years ahead of his time. And foolish ridicule by our latter day arm-chair "savants," does not in the least mar Tesla's greatness.

The titanic brain of Tesla has hardly produced a more amazing wonder than this "magnifying transmitter." Contrary to popular belief his tower was not built to radiate Hertzian waves into the ether. Tesla's system sends out thousands of horsepower thru the earth—he has shown experimentally how power can be sent without wires over distances from a central point. Nor is there any mystery about it how he accomplishes the result. His historic U. S. patents and articles describe the method used. Tesla's Magnifying Transmitter is truly a modern lamp of Aladdin.

EDITOR.

"Aladdin's Lamp".

These and other inventions of mine, however, were nothing more than steps forward in certain directions. In evolving them I simply followed the inborn instinct to improve the present devices without

(*Continued on page* 148)

Mr. Tesla's articles started in our February issue

THIS PHOTOGRAPH OF A MODEL SHOWS HOW THE TESLA TOWER BUILT ON LONG ISLAND, EIGHTEEN YEARS AGO, WOULD HAVE LOOKED COMPLETED. FROM ITS APPEARANCE NOBODY WOULD INFER THAT IT WAS TO BE USED FOR THE GREAT PURPOSES WHICH ARE SET FORTH IN HIS ACCOMPANYING ARTICLE.

The Moon's Rotation

By NIKOLA TESLA

In this article Dr. Tesla proves conclusively by theory and experiment that all the kinetic energy of a rotating mass is purely translational and that the moon contains absolutely no rotational energy, in other words, does not rotate on its axis.—EDITOR.

IN revising my article on "The Moon's Rotation", which appeared in the April issue of the ELECTRICAL EXPERIMENTER, I appended a few remarks to the original text in further support and elucidation of the theory advanced. Due to the printer's error these were lost and, in consequence, I found it necessary to forward another communication which, unfortunately, was received too late for embodiment in the May number. Meanwhile many letters have reached me in which certain phenomena presented by rotating bodies, as the moon's librations of longitude, are cited as evidences of energy due to spinning motion, i. e., proofs of axial rotation of the satellite in the true physical sense. I trust that the following amplified statement will meet all of the objections raised and convert to my views those who are still unconvinced.

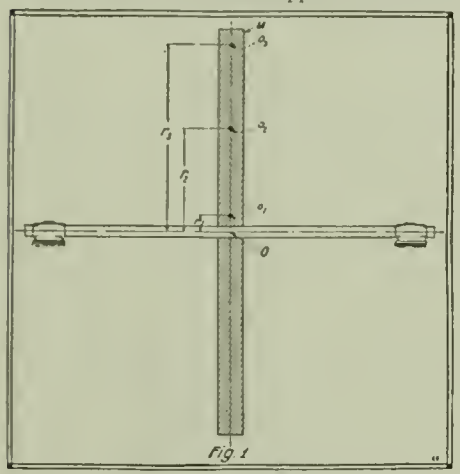


Fig. 1. In Determining the Kinetic Energy of a Rotating Mass, This Figure Shows the Selection of a Number of Points Taken Within the Straight Rod or Mass M, at Successive Distances from the Axis of Rotation O. Knowing These Values and the Speed of Rotation the Kinetic Energy of the Mass Is Readily Computed.

The kinetic energy of a rotating mass can be determined in four ways which are illustrated in diagrams, Figs. 1, 2, 3 and 4 and may be found more or less suitable.

Referring to Fig. 1, the method consists in selecting judiciously a number of points as o_1, o_2, o_3, etc., within the straight rod or mass M, respectively at distances r_1, r_2, r_3, etc., from the axis of rotation 0 and calculating the square root of the mean square of these distances. Its value being R_s, denoted radius of gyration, the *effective* velocity of the mass at n revolutions per second will be $V_e = 2\pi R_s n$ and its kinetic energy $E = \frac{1}{2} M V_e^2 = \frac{1}{2} M (2\pi R_s n)^2$.

In Fig. 2 the mass M, rotating n times per second about an axis 0 at right angles to the plane of the paper, is divided into numerous elements or small parts, most conveniently very thin concentric laminae, as l_1, l_2, l_3, etc., at distances r_1, r_2, r_3, etc., from 0. Since the kinetic energy of each part is equal to half the product of its mass and the square of the velocity, the sum of all these elemental energies $E = \frac{1}{2} \Sigma m V^2 = \frac{1}{2} m_1 V_1^2 + \frac{1}{2} m_2 V_2^2 + \frac{1}{2} m_3 V_3^2 + \ldots\ldots = \frac{1}{2} m_1 (2\pi r_1 n)^2 + \frac{1}{2} m_2 (2\pi r_2 n)^2 + \frac{1}{2} m_3 (2\pi r_3 n)^2 + \ldots\ldots$

A different form of expression for the energy of a rotating body may be obtained by determining its moment of inertia. For this purpose the mass M (in Fig. 3), rotating n times per second about an axis 0, is separated into minute parts, as m_1, m_2, m_3, etc., respectively at distances r_1, r_2, r_3, etc., from the same. The sum of the products of all these small masses and the squares of their distances is the moment of inertia I, and then $E = \frac{1}{2} I \omega^2$, $\omega = 2\pi n$ being the angular velocity.

It is obvious that in all these instances many points or elements will be required for great accuracy but, as a rule, very few are sufficient in practice.

Still another way to compute the kinetic energy is illustrated in Fig. 4, in which case the quantity I is given in terms of the moment of inertia I_c about another axis parallel to 0 and passing thru the center of gravity C of mass M. In conformity with this the energy of motion $E = \frac{1}{2} M V^2 + \frac{1}{2} I_c \omega^2$ in which equation V is the velocity of the center of gravity.

The preceding is deemed indispensable as I note that the correspondents, even those who seem thoroly familiar with mechanical principles, fail to make a distinction between theoretical and physical truths which is essential to my argument.

In estimating the kinetic energy of a rotating mass in any of the ways indicated we arrive, thru suitable conceptions and methods of approximation, at expressions which may be made quantitatively precise to any desired degree, but do not truly define the actual condition of the body. To illustrate, when proceeding according to the plan of Fig. 1, we find a certain hypothetical velocity with which the entire mass should move in order to contain the same energy, a state wholly imaginary and irreconcilable with the actual. Only, when *all* particles of the body have the same velocity, does the product $\frac{1}{2} M V^2$ specify a physical fact and is numerically and descriptively accurate. Still more remote from palpable truth is the equation of motion obtained in the manner indicated in Fig. 4, in which the first term represents the kinetic energy of translation of the body as a whole and the second that of its axial rotation. The former would demand a movement of the mass in a definite path and direction, all particles having the same velocity, the latter its simultaneous motion in another path and direction, the particles having different velocities. This abstract idea of angular motion is chiefly responsible for the illusion of the moon's axial rotation, which I shall endeavor to dispel by additional evidences.

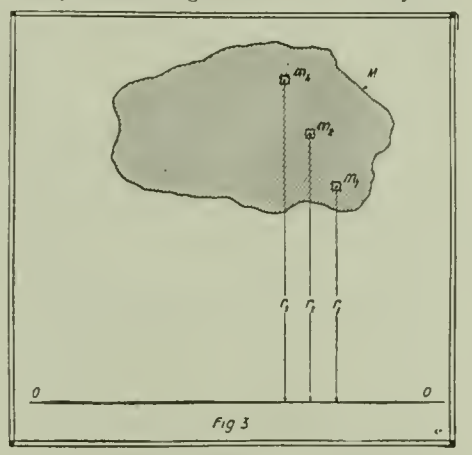


Fig. 3. Another Form of Expression for the Energy of a Rotating Body May Be Obtained by Determining Its Moment of Inertia. Here the Mass M Is Subdivided Into Minute Parts m_1, m_2, m_3, ... etc. The Sum of the Products of These Masses and the Squares of Their Distances Is the Moment of Inertia, Which with the Angular Speed, Gives the Kinetic Energy E.

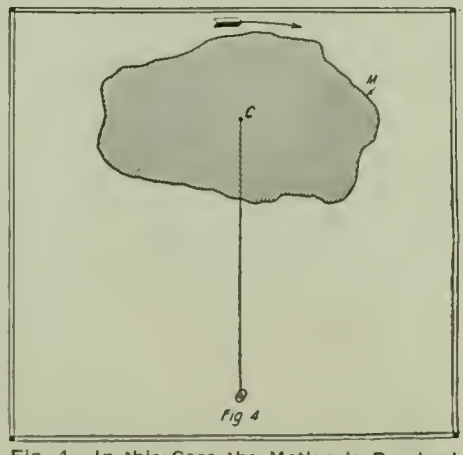


Fig. 4. In this Case the Motion Is Resolved Into Two Separate Components—One Translational About O and the Other Rotational About C. The Total Kinetic Energy of the Mass Equals the Sum of These Two Energies.

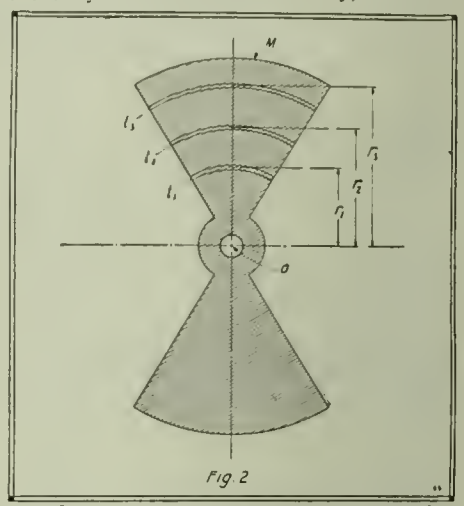


Fig. 2. In This Case the Mass M, Rotating n Times Per Second, About An Axis O, Is Divided Into Numerous Elements or Small Parts at Various Radii from O. Knowing the Kinetic Energy of Each Part, the Whole Kinetic Energy of the Mass Is Easily Determined by Taking a Summation of the Individual Quantities.

With this object attention is called to Fig. 5 showing a system composed of eight balls M, which are carried on spokes S, radiating from a hub H, rotatable around a central axis 0 in bearings supposed to be frictionless. It is an arrangement similar to that before illustrated with the exception that the balls, instead of forming parts of the spokes, are supported in screw pivots *s*, which are normally loose but can be tightened so as to permit both free turning and rigid fixing as may be desired. To facilitate observation the spokes are provided with radial marks and the lower sides of the balls are shaded. Assume, first, that the drawing depicts the state of rest, the balls being rotatable without friction, and let an angular velocity $\omega = 2\pi n$ be imparted to the system in the clockwise direction as indicated by the long solid arrow. Viewing a ball as M, its successive positions 1, 2, 3—8 in space, and also relatively to the spoke, will be just as drawn, and it is evident from an inspection of the diagram that while moving with the angular velocity ω about 0, in the clockwise direction, the ball turns, with respect to its axis, at the same angular velocity but in the opposition direction, that of the dotted arrow. The combined result of these two motions is a translatory movement of the ball such that all particles are animated with the same velocity V, which is that of its center of gravity. In this case, granted that there is absolutely no friction the

kinetic energy of each ball will be given by the product of ½ M V² not approximately, but with mathematical rigor. If now the pivots are screwed tight and the balls fixt rigidly to the spokes, this angular motion relatively to their axes becomes physically impossible and then it is found that the kinetic energy of each ball is increased, the increment being exactly the energy of rotation of the ball on its axis. This fact, which is borne out both by theory and experiment, is the foundation of the general notion that a gyrating body—in this instance ball M—presenting always the same face towards the center of motion, *actually* rotates upon its axis in the same sense, as indicated by the short full arrow. *But it does not tho to the eye it seems so.* The fallacy will become manifest on further inquiry.

To begin with, observe that when a mass, say the armature of an electric motor, rotating with the angular velocity ω, is reversed, its speed is $-\omega$ and the difference $\omega - (-\omega) = 2\omega$. Now, in fixing the ball to the spoke, the change of angular velocity is only ω; therefore, an additional velocity ω would have to be imparted to it in order to cause a clockwise rotation of the ball on its axis in the true significance of the word. The kinetic energy would then be equal to the sum of the energies of the translatory and axial motions, not merely in the abstract mathematical meaning, but as a physical fact. I am well aware that, according to the prevailing opinion, when the ball is free on the pivots it does not turn on its axis at all, and only rotates with the angular velocity of the frame when rigidly attached to the same, but the truth will appear upon a closer examination of this kind of movement.

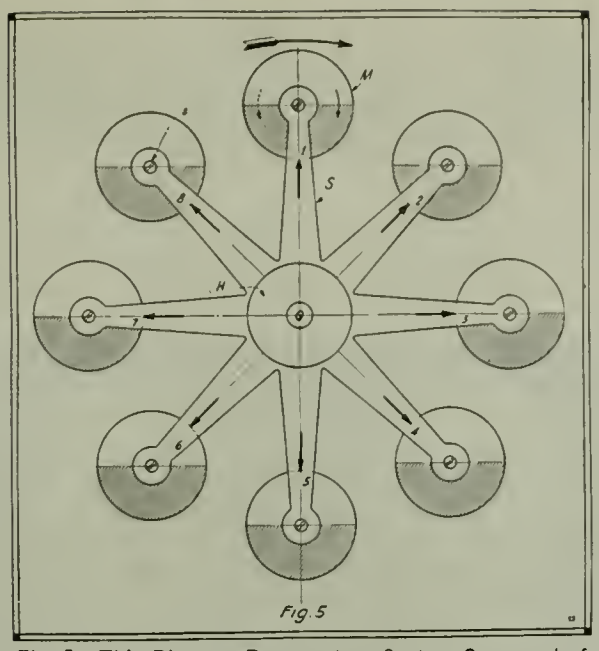


Fig. 5. This Diagram Represents a System Composed of 8 Balls M, Carried on Spokes S, and Rotating Around Center O. The Balls Are Freely Rotatable on Pivots Which Can Be Tightened. With This Model the Fallacy of the Moon's Rotation on Its Axis Is Demonstrable.

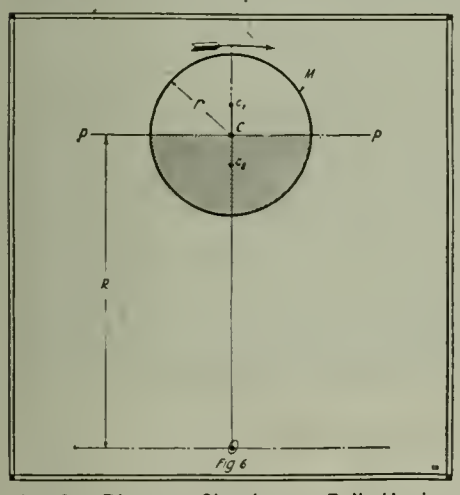


Fig. 6. Diagram Showing a Ball Having Mass M, of Radius r, Rotating About Center O, and Used in the Theoretical Analysis of the Moon's Motion.

Let the system be rotated as first assumed and illustrated, the balls being perfectly free on the pivots, and imagine the latter to be gradually tightened to cause friction slowly reducing and finally preventing the slip. At the outset all particles of each ball have been moving with the speed of its center of gravity, but as the bearing resistance asserts itself more and more the translatory velocity of the particles nearer to the axis 0 will be *diminishing*, while that of the diametrically opposite ones will be *increasing*, until the maxima of these changes are attained when the balls are firmly held. In this operation we have thus deprived those parts of the masses which are nearer to the center of motion, of some kinetic energy of *translation* while adding to the energy of those which are farther and, obviously, the gain was greater than the loss so that the *effective* velocity of each ball as a whole was increased. *Only so* have we augmented the kinetic energy of the system, not by causing *axial rotation* of the balls. The energy E of each of these is *solely* that of translatory movement with an effective velocity V_e as above defined such that $E = \frac{1}{2} M V_e^2$. The axial rotations of the ball in either direction are but apparent; *they have no reality whatever* and call for no mechanical effort. It is merely when an extraneous force acts independently to turn the whirling body on its axis that energy comes into play. Incidentally it should be pointed out that in true axial rotation of a rigid and homogenous mass all symmetrically situated particles contribute equally to the momentum which is not the case here. That there exists not even the slightest tendency to such motion can, however, be readily established.

For this purpose I would refer to Fig. 6 showing a ball M of radius *r*, the center C of which is at a distance R from axis 0 and which is bisected by a tangential plane *pp* as indicated, the lower half sphere being shaded for distinction. The kinetic energy of the ball when whirled *n* times per second about 0 is according to the first form of expression $E = \frac{1}{2} M V_e^2 = \frac{1}{2} M (2\pi R_g n)^2$, M being the mass and R_g the radius of gyration. But, as explained in connection with Fig. 4, we have also $E = \frac{1}{2} M V^2 + \frac{1}{2} I_c \omega^2, V = 2\pi R n$ being the velocity of the center of gravity C and I_c the moment of inertia of the ball, about the parallel axis passing thru C and equal to $\frac{2}{5} M i^2$ so that $E = \frac{1}{2} M (2\pi R n)^2 + \frac{1}{5} M r^2 (2\pi n)^2$. Neither of these two expressions for E describes the actual state of the body but the first is certainly preferable conveying, as it does, the idea of a single motion instead of two, one of which moreover is devoid of existence. I shall first undertake to demonstrate that there is no torque or rotary effort about center C and that the kinetic energy of the supposed axial rotation of the ball is mathematically equal to zero. This makes it necessary to consider the two halves separated by the tangential plane *pp* wholly independent from one another. Let c_1 and c_2 be their centers of gravity, then $Cc_1 = Cc_2 = \frac{3}{8} r$. In order to ascertain the kinetic energy of the hemispheres we have to find their radii of gyration which can be done by determining the moments of inertia Ic_1 and Ic_2 about parallel axes passing thru c_1 and c_2. Complex calculation will be avoided by remembering that the moment of inertia of either one of the half spheres about an axis thru C is $I_C = \frac{1}{2} \times \frac{2}{5} M r^2, = \frac{1}{5} M r^2$, and since $M = 2 m$, $I_C = \frac{2}{5} m r^2$. This can be exprest in terms of the moments Ic_1 and Ic_2; namely, $I_C = Ic_1 + m (\frac{3}{8} r)^2 = Ic_2 + m (\frac{3}{8} r)^2$. Hence $Ic_1 = Ic_2 = I_C - m (\frac{3}{8} r)^2 = \frac{2}{5} m r^2 - 9/64 m r^2 = 83/320 m r^2$. Following the same rule the moments of inertia of the half spheres about the axis passing thru the center of motion 0 can be found. Designating the moments for the upper and lower halves of the ball, respectively, I_{O1} and I_{O2} we have $I_{O1} = m (R + \frac{3}{8} r)^2 + Ic_1 = m (R + \frac{3}{8} r)^2 + 83/320 m r^2$ and $I_{O2} = m (R - \frac{3}{8} r)^2 + Ic_2 = m (R - \frac{3}{8} r)^2 + 83/320 m r^2$. Thus for the upper half sphere the radius of gyration $R_{g1} =$

$$\sqrt{\frac{I_{O1}}{m}} = \sqrt{(R + \tfrac{3}{8} r)^2 + 83/320\ r^2}$$

and for the lower one $R_{g2} =$

$$\sqrt{\frac{I_{O2}}{m}} = \sqrt{(R - \tfrac{3}{8} r)^2 + 83/320\ r^2}$$

These are the distances from center 0, at which the masses of the half spheres may be concentrated and then the algebraic sum of their energies—which are wholly translatory those of axial rotation being nil—will be exactly equal to the total kinetic energy of the ball as a unit. The

(*Continued on page* 156)

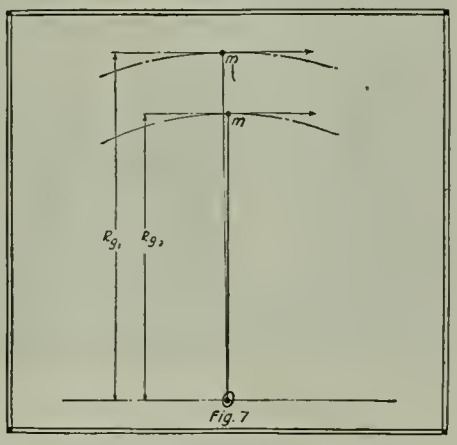


Fig. 7. Here Two Masses m-m, Are Considered as Condensed Into Points, Attached to Weightless Strings of Different Radii. If Both Strings Are Cut, and the Masses Considered as Joined, Then There Will Be No Rotation About the Common Center of Gravity.

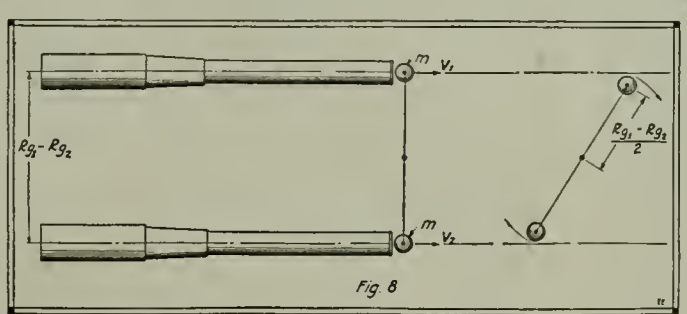
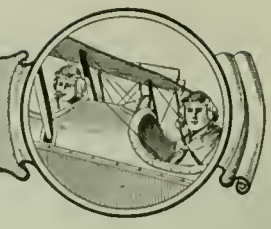
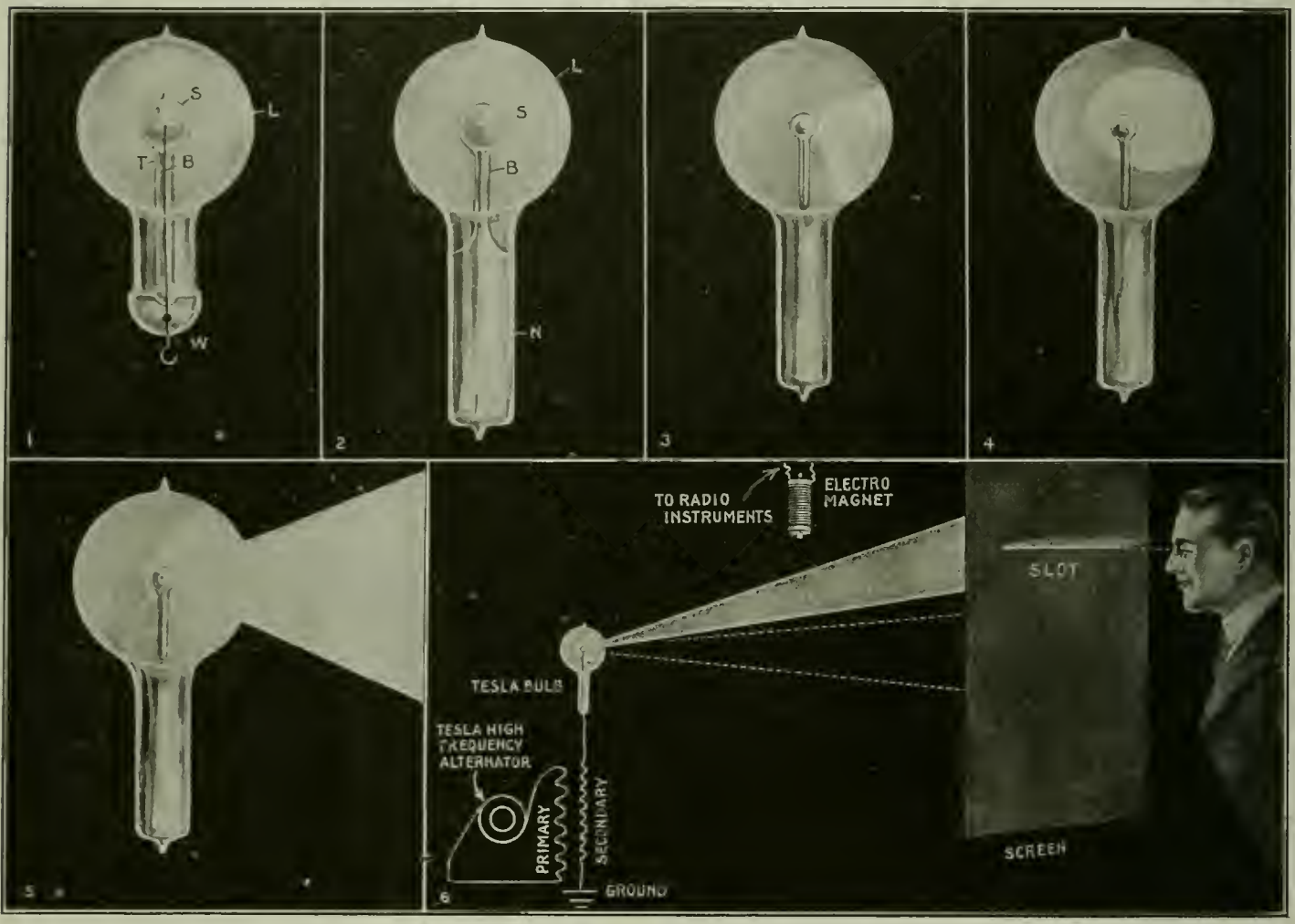


Fig. 8. To Make the Problem Shown in Fig. 7 Clear, Imagine Two Rifle Barrels Parallel to Each Other. If Two Balls M-M Are Fired Simultaneously, Joined by a Theoretical Bond, They Will Revolve About Their Common Center of Gravity, Proving That the Moon Possesses Only Kinetic Energy of Translation.

RADIO DEPARTMENT



Tesla Bulbs



Early In Nikola Tesla's Researches—In Fact as Far Back as 1892—He Discovered a Most Peculiar and Wonderful Vacuum Bulb Phenomena. The Effect was That, Under Certain Critical Conditions, This Bulb Would Cause a Ray to Be Shot off in the Manner Shown, Which Ray Would Revolve or Oscillate Under the Influence of a High-Frequency Current and in Synchrony with It. By Utilizing This Principle, Dr. Tesla Believes It is Possible to Produce a Radio Detector More Sensitive Than the Audion or Fleming Valve.

IN the May issue in his article, "True Wireless," Nikola Tesla mentions the forerunner of the Audion, a Vacuum Bulb, which he used in his earlier experiments.

We have been in receipt of numerous letters from many individuals interested in this bulb who desire further particulars as to its operation, etc.

Accordingly, we publish herewith some excerpts from a lecture by Dr. Tesla delivered before the Institution of Electrical Engineers and Royal Institution, London, February, 1892.

"I think it best at this juncture to bring before you a phenomenon, observed by me some time ago, which to the purely scientific investigator may perhaps appear more interesting than any of the results which I have the privilege to present to you this evening.

"It may be quite properly ranked among the brush phenomena—in fact, it is a brush, formed at, or near, a single terminal in high vacuum.

"In bulbs provided with a conducting terminal, tho it be of aluminum, the brush has but an ephemeral existence, and cannot, unfortunately, be indefinitely preserved in its most sensitive state, even in a bulb devoid of any conducting electrode. In studying the phenomenon, by all means a bulb having no leading-in wire should be used. I have found it best to use bulbs constructed as indicated in Figs. 1 and 2.

"In Fig. 1 the bulb comprises an incandescent lamp globe L, in the neck of which is sealed a barometer tube b, the end of which is blown out to form a small sphere *s*. This sphere should be sealed as closely as possible in the center of the large globe. Before sealing, a thin tube *t*, of aluminum sheet, may be slipt in the barometer tube, but it is not important to employ it.

"The small hollow sphere *s* is filled with some conducting powder, and a wire *w* is cemented in the neck for the purpose of connecting the conducting powder with the generator.

"The construction shown in Fig. 2 was chosen in order to remove from the brush any conducting body which might possibly affect it. The bulb consists in this case of a lamp globe L, which has a neck *n*, provided with a tube *b* and small sphere *s*, sealed to it, so that two entirely independent compartments are formed, as indicated in the drawing. When the bulb is in use the neck *n* is provided with a tinfoil coating, which is connected to the generator and acts inductively upon the moderately rarefied and highly conducting gas inclosed in the neck. From there the current passes thru the tube *b* into the small sphere *s*, to act by induction upon the gas contained in the globe L.

"It is of advantage to make the tube *t* very thick, the hole thru it very small, and to blow the sphere *s* very thin. It is of the greatest importance that the sphere *s* be placed in the center of the globe L.

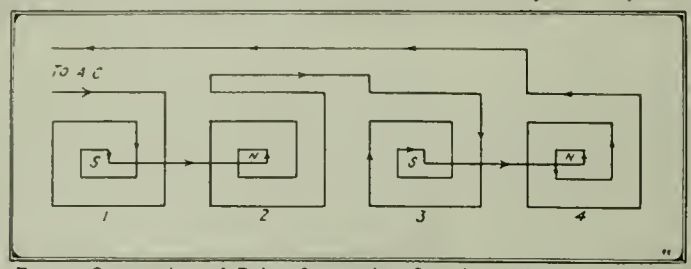
"Figs. 3, 4, 5, indicate different forms, or stages, of the brush. Fig. 1 shows the brush as it first appears in a bulb provided with a conducting terminal; but, as in such a bulb it very soon disappears—often after a few minutes—I will confine myself to the de-

(*Continued on page* 179)

The Oracle

(*Continued from page* 146)

as the diagram shows. Those you show in your letter are not correct, for they give like polarity on each pole, which is wrong. We have no data on the starting coil dimensions, but you can arrive at this by experiment, or else by getting in touch with the manufacturers of a similar sized motor.



Proper Connection of Poles Composing Starting Winding of Induction Motor.

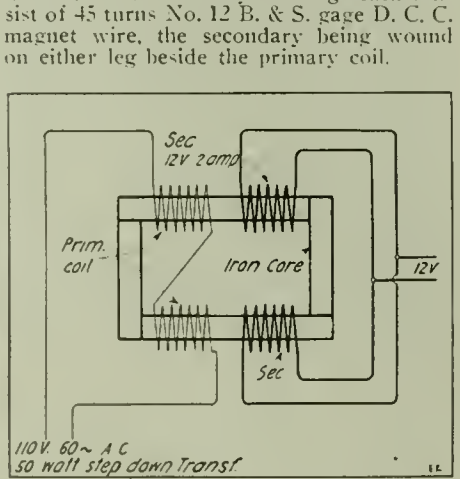
SPECIAL 110 VOLT TO 12 VOLT A. C. TRANSFORMER.

(1010) August Kling, Mobile, Ala., writes:

Q. 1. Asking for data on building a small step-down transformer to give 12 volts at the secondary, which he desires split into two coils. Total output 50 watts.

A. 1. We give herewith data on double wound closed core transformer to step-down 110 volts 60 cycle A. C. to a maximum secondary voltage of 12 volts.

The laminated sheet iron core for this transformer may measure 5 inches wide by 6 inches long, and have a cross-section of 1 inch by ½ inch. At either end of the two longer legs, as the diagram herewith shows, two primary windings may be placed, each of them consisting of 200 turns of No. 18 D. C. C. magnet wire. At either end of the two long legs, the two secondary windings may be placed, as the diagram shows, each of these developing about 12 volts and about 2 amperes, or giving 12 volts and 4 amperes or 50 watts, the total output you request for both secondaries connected in parallel. It is understood that both primaries in this design are to be connected in series on 110 volt 60 cycle A. C. at all times, i.e., whenever the transformer is used. The secondary windings each consist of 45 turns No. 12 B. & S. gage D. C. C. magnet wire, the secondary being wound on either leg beside the primary coil.



Details of 110-Volt to 12-Volt A. C. Transformer. Secondary Coils May Be Connected In Parallel or In Series.

With respect to taking off taps on the secondary for different voltages, you can easily divide up the total number of turns on the secondary yourself by means of a small battery voltmeter. You can readily test the potential by experiment. The voltage in any case is directly proportionate to the number of turns in use.

100-WATT, 32 TO 8-VOLT STEP-DOWN TRANSFORMER.

(1011) Claude Carefoot, Pasqua, Sask., Canada, inquires:

Q. 1. For data on step-down transformer to reduce 32 volts to 8 volts, A. C.

A. 1. We do not of course know how many watts you wish the transformer to carry, but we give you herewith data on a 100-watt transformer. The laminated sheet iron core may be about 8" long by 6" wide and thickness of 1". The core should have a cross-section of 1 square inch. The primary winding, on one leg of the transformer, should consist of 230 turns of No. 11 D.C.C. magnet wire.

The secondary winding should have 58 turns of No. 5 D.C.C. magnet wire.

My Inventions
By Nikola Tesla

(*Continued from page* 112)

any special thought of our far more imperative necessities. The "Magnifying Transmitter" was the product of labors extending through years, having for their chief object the solution of problems which are infinitely more important to mankind than mere industrial development.

If my memory serves me right, it was in November, 1890, that I performed a laboratory experiment which was one of the most extraordinary and spectacular ever recorded in the annals of science. In investigating the behaviour of high frequency currents I had satisfied myself that an electric field of sufficient intensity could be produced in a room to light up electrodeless vacuum tubes. Accordingly, a transformer was built to test the theory and the first trial proved a marvelous success. It is difficult to appreciate what those strange phenomena meant at that time. We crave for new sensations but soon become indifferent to them. The wonders of yesterday are today common occurrences. When my tubes were first publicly exhibited they were viewed with amazement impossible to describe. From all parts of the world I received urgent invitations and numerous honors and other flattering inducements were offered to me, which I declined.

In Faraday's Chair

But in 1892 the demands became irresistible and I went to London where I delivered a lecture before the Institution of Electrical Engineers. It had been my intention to leave immediately for Paris in compliance with a similar obligation, but Sir James Dewar insisted on my appearing before the Royal Institution. I was a man of firm resolve but succumbed easily to the forceful arguments of the great Scotchman. He pushed me into a chair and poured out half a glass of a wonderful brown fluid which sparkled in all sorts of iridescent colors and tasted like nectar. "Now," said he, "you are sitting in Faraday's chair and you are enjoying whiskey he used to drink." In both aspects it was an enviable experience. The next evening I gave a demonstration before that Institution, at the termination of which Lord Rayleigh addressed the audience and his generous words gave me the first start in these endeavors. I fled from London and later from Paris to escape favors

(*Continued on page* 173)

The Moon's Rotation

By Nikola Tesla

(*Continued from page* 133)

significance of this will be understood by reference to Fig. 7 in which the two masses, condensed into points, are represented as attached to independent weightless strings of lengths R_{g1} and R_{g2} which are purposely shown as displaced but should be imagined as coincident. It will be readily seen that if both strings are cut in the same instant the masses will fly off in tangents to their circular orbits, the angular movement becoming rectilinear without any transformation of energy occurring. Let us now inquire what will happen if the two masses are rigidly joined, the connection being assumed imponderable. *Here we come to the real bug in the question under discussion.* Evidently, so long as the whirling motion continues, and both the masses have precisely the same angular velocity, this connecting link will be of no effect whatever, not the slightest turning effort about the common center of gravity of the masses or tendency of equalization of energy between them will exist. The moment the strings are broken and they are thrown off they will begin to rotate but, as pointed out before, this motion neither adds to or detracts from the energy stored. **The rotation is, however, not due to an exclusive virtue of angular motion, but to the fact that the tangential velocities of the masses or parts of the body thrown off are different.**

To make this clear and to investigate the effects produced, imagine two rifle barrels, as shown in Fig. 8, placed parallel to each other with their axes separated by a distance $R_{g1} - R_{g2}$ and assume that two balls of same diameter, each having mass m, are discharged with muzzle velocities V_1 and V_2, respectively equal to $2\pi n R_{g1}$ and $2\pi n R_{g2}$ as in the case just considered. If it be further supposed that at the instant of leaving the barrels the balls are joined by a rigid but weightless link they will rotate about their common center of gravity and in accordance with the statement in my previous article above mentioned, the relation will exist $\frac{V_1 - V_2}{2} = \pi n (R_{g1} - R_{g2})$ n being the number of revolutions per second. The equalization of the speeds and kinetic energies of the balls will be, under these circumstances, very rapid but in two heavenly bodies linked by gravitational attraction, the process might require ages. Now, this whirling movement is real and requires energy which, obviously, must be derived from that originally imparted and, consequently, must reduce the velocity of the balls in the direction of flight by an amount which can be easily calculated. At the moment of discharge the total kinetic energy was $E = \frac{1}{2} m V_1^2 + \frac{1}{2} m V_2^2$ which is evidently equal to $m V_3^2$, V_3 being the effective velocity of the common center of gravity, from which follows that $V_3 = \sqrt{\frac{V_1^2 + V_2^2}{2}}$. The speed of revolution of the masses is, of course, $\frac{V_1 - V_2}{2}$ and the rotational energy of both balls, which must be considered as points, is $e = m\left(\frac{V_1 - V_2}{2}\right)$ The kinetic energy of translation in the direction of flight is then $\frac{1}{2} m V_1^2 + \frac{1}{2} m V_2^2 - m\left(\frac{V_1 - V_2}{2}\right)^2 = m\left(\frac{V_1 + V_2}{2}\right)^2 = m V_4^2$, $V_4 = \frac{V_1 - V_2}{2}$ being the speed of the

common center of gravity, so that $V_2 - V_1$ is the loss of velocity in the direction of flight owing to the rotation of the two mass points. If instead of these we would deal with the balls as they are, their rotational energy

$$e_1 = e + i\omega_1^2 = m\left(\frac{V_1 + V_2}{2}\right)^2 + i(2\pi n)^2$$

i being the moment of inertia of each ball about its axis.

As will be seen, we arrive at precisely the same results whether the movement is rectilinear or in a circle. In both cases the total kinetic energy can be divided into two parts, respectively of the same numerical values, *but there is an essential difference.* In angular motion the axial rotation is nothing more than an *abstract conception;* in rectilinear movement it is a *positive event.*

Virtually all satellites rotate in like manner and the probability, that the acceleration or retardation of their axial motions—if they ever existed—should come to a stop precisely at a definite angular velocity, is infinitesimal while it is almost absolutely certain that all movement of this kind would ultimately cease. The most plausible view is that no true moon has ever rotated on its axis, for at the time of its birth there must have been some deformation and displacement of its center of gravity thru the attractive force of the mother planet so as to make its peculiar position in space, relative to the latter, in which it persists irrespective of distance, more or less stable. In explanation of this, suppose that one of the balls as M in Fig 5 is not of homogenous material and that it is similarly supported but on an axis passing thru its center of gravity instead of form. Then, no matter in what position the ball is fixed on the pivots, its kinetic energy and centrifugal pull will be the same. Nevertheless a directive tendency will exist as the two centers do not coincide and there is, consequently, no *dynamic* balance. When permitted to turn freely on the axis of gravity the body, of whatever shape it may be, will tend to place itself so that the line joining the two centers points to O and there may be two positions of stability but, generally, if the center of gravity is not greatly displaced, the heavier side will swing outwardly. Such condition may obtain in the moon if it had solidified before receding from the earth to great distance, when the

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POPULAR ASTRONOMY

The Evolution of the Stars

(Continued from page 121)

Canopus, one of the giants of the universe. The transition of this type into the solar type stars of class G, to which our sun belongs, occurs when the group of iron lines known as group G begins to appear (see diagram 1). The lines of calcium and hydrogen still remain more intense than any other lines in the spectrum, but many fine metallic lines now appear in ever-increasing intensity. The transition of this type into the advanced solar type K occurs when some of the metallic lines surpass the hydrogen lines in intensity. The group of iron lines has also greatly increased in intensity until it becomes one of the most conspicuous features of the K type stars. Stars of the solar type such as Capella and the sun are yellow, and stars of the advanced solar type, such as Arcturus and Aldebaran, are orange colored bordering on red. Their atmospheres are filled with dense metallic vapors. (See photos of solar and advanced solar type spectra.)

Class M is divided into giant and dwarf

The Moon's Rotation

By Nikola Tesla

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arrangement of the masses in its interior became subject to gravitational forces of its own, vastly greater than the terrestrial. It has been suggested that the planet is egg-shaped or ellipsoidal but the departure from spherical form must be inconsiderable. It may even be a perfect sphere with the centers of gravity and symmetry coinciding and still rotate as it does. Whatever be its origin and past history, the fact is, that at present all its parts have the same angular velocity as though it were rigidly connected with the earth. This state must endure forever unless forces from without the luna-terrestrial system bring about different conditions and thus the hope of the star-gazers that its other side may become visible some day must be indefinitely deferred.

A motion of this character, as I have shown, precludes the possibility of axial rotation. The easiest way to free ourselves of this illusion is to conceive the satellite subdivided into minute and entirely independent parts, as dust particles, which have different orbital, but rigorously the same angular, velocities. One must at once recognize that the kinetic energy of such an agglomeration is solely translational, there being absolutely no tendency to axial rotation. This makes it also perfectly clear why the moon, provided its distance does not greatly increase, *must* always turn the same face to us even *without any inherent directive tendency* nor so much as *the slightest effort from the earth.*

Referring to the librations of longitude, I do not see that they have any bearing on this question. In astronomical treatises the axial rotation of the moon is accepted as a material fact and it is thought that its angular velocity is constant while that of the orbital movement is not, this resulting in an apparent oscillation revealing more of its surface to our view. To a degree this may be true, but I hold that the mere change of orbital velocity, as will be evident from what has been stated before could not produce these phenomena, for no matter how fast or slow the gyration, the position of the body relative to the center of attraction remains the same. The real cause of these axial displacements is the changing distance of the moon from the earth owing to which the tangential components of velocity of its parts are varied. In *apogee*, when the planet recedes, the radial component of velocity decreases while the tangential increases but, as the decrement of the former is the same for all parts, this is more pronounced in the regions facing the earth than in those turned away from it, the consequence being an axial displacement exposing more of the eastern side. In *perigee*, on the contrary, the radial component increases and the effect is just the opposite with the result that more of the western side is seen. The moon actually swings on the axis passing thru its center of gravity on which it is supported like a ball on a string. The forces involved in these pendular movements are incomparably smaller than those required to effect changes in orbital velocity. If we estimate the radius of gyration of the satellite at 600 miles and its mean distance from the earth at 240,000 miles, then the energy necessary to rotate it once in a month would be only

$$\left(\frac{600}{240{,}000}\right)^2 = \frac{1}{160{,}000}$$ of the kinetic energy

of the orbital movement.

My Inventions

By Nikola Tesla

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showered upon me, and journeyed to my home where I passed through a most painful ordeal and illness. Upon regaining my health I began to formulate plans for the resumption of work in America. Up to that time I never realized that I possessed any particular gift of discovery but Lord Rayleigh, whom I always considered as an ideal man of science, had said so and if that was the case I felt that I should concentrate on some big idea.

Nature's Trigger.

One day, as I was roaming in the mountains, I sought shelter from an approaching storm. The sky became overhung with heavy clouds but somehow the rain was delayed until, all of a sudden, there was a lightning flash and a few moments after a deluge. This observation set me thinking. It was manifest that the two phenomena were closely related, as cause and effect, and a little reflection led me to the conclusion that the electrical energy involved in the precipitation of the water was inconsiderable, the function of lightning being much like that of a sensitive trigger. Here was a stupendous possibility of achievement. If we could produce electric effects of the required quality, this whole planet and the conditions of existence on it could be transformed. The sun raises the water of the oceans and winds drive it to distant regions where it remains in a state of most delicate balance. If it were in our power to upset it when and wherever desired, this mighty life-sustaining stream could be at will controlled. We could irrigate arid deserts; create lakes and rivers and provide motive power in unlimited amounts. This would be the most efficient way of harnessing the sun to the uses of man. The consummation depended on our ability to develop electric forces of the order of those in nature. It seemed a hopeless undertaking, but I made up my mind to try it and immediately on my return to the United States, in the summer of 1892, work was begun which was to me all the more attractive, because a means of the same kind was necessary for the successful transmission of energy without wires.

Four Million Volts.

The first gratifying result was obtained in the spring of the succeeding year when I reached tensions of about 1,000,000 volts with my conical coil. That was not much in the light of the present art, but it was then considered a feat. Steady progress was made until the destruction of my laboratory by fire in 1895, as may be judged from an article by T. C. Martin which appeared in the April number of the *Century Magazine*. This calamity set me back in many ways and most of that year had to be devoted to planning and reconstruction. However, as soon as circumstances permitted, I returned to the task. Although I knew that higher electro-motive forces were attainable with apparatus of larger dimensions, I had an instinctive perception that the object could be accomplished by the proper design of a comparatively small and compact transformer. In carrying on tests with a *secondary in the form of a flat spiral*, as illustrated in my patents, the absence of streamers surprised me, and it was not long before I discovered that this was due to the position of the turns and their mutual action. Profiting from this observation I resorted to the use of a high tension conductor with turns of considerable diameter sufficiently separated to keep down the distributed capacity, while at the

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My Inventions

By Nikola Tesla

(*Continued from page* 173)

same time preventing undue accumulation of the charge at any point. The application of this principle enabled me to produce pressures of 4,000,000 volts, which was about the limit obtainable in my new laboratory at Houston Street, as the discharges extended through a distance of 10 feet. A photograph of this transmitter was published in the *Electrical Review* of November, 1898. In order to advance further along this line I had to go into the open, and in the spring of 1899, having completed preparations for the erection of a wireless plant, I went to Colorado where I remained for more than one year. Here I introduced other improvements and refinements which made it possible to generate currents of any tension that may be desired. Those who are interested will find some information in regard to the experiments I conducted there in my article, "The Problem of Increasing Human Energy" in the *Century Magazine* of June, 1900, to which I have referred on a previous occasion.

The Magnifying Transmitter.

I have been asked by the ELECTRICAL EXPERIMENTER to be quite explicit on this subject so that my young friends among the readers of the magazine will clearly understand the construction and operation of my "Magnifying Transmitter" and the purposes for which it is intended. Well, then, in the first place, it is a *resonant transformer* with a secondary in which the parts, charged to a high potential, are of considerable area and arranged in space along ideal enveloping surfaces of very large radii of curvature, and at proper distances from one another thereby insuring a *small electric surface density everywhere* so that *no leak can occur even if the conductor is bare*. It is suitable for any frequency, from a few to many thousands of cycles per second, and can be used in the production of currents of tremendous volume and moderate pressure, or of smaller amperage and immense electro-motive force. The maximum electric *tension is merely dependent on the curvature of the surfaces* on which the charged elements are situated and the area of the latter.

100 Million Volts Possible.

Judging from my past experience, as much as 100,000,000 volts are perfectly practicable. On the other hand currents of many thousands of amperes may be obtained in the antenna. A plant of but very moderate dimensions is required for such performances. Theoretically, a terminal of less than 90 feet in diameter is sufficient to develop an electro-motive force of that magnitude while for antenna currents of from 2,000-4,000 amperes at the usual frequencies it need not be larger than 30 feet in diameter.

In a more restricted meaning this wireless transmitter is one in which the Hertz-wave radiation is an entirely negligible quantity as compared with the whole energy, under which condition the damping factor is extremely small and an enormous charge is stored in the elevated capacity. Such a circuit may then be excited with impulses of any kind, even of low frequency and it will yield sinusoidal and continuous oscillations like those of an alternator.

Taken in the narrowest significance of the term, however, it is a resonant transformer which, besides possessing these qualities, is accurately proportioned to fit the globe and its electrical constants and properties, by virtue of which design it becomes highly efficient and effective in the

wireless transmission of energy. Distance is then absolutely eliminated, there being *no diminution in the intensity of the transmitted impulses.* It is even possible to make the actions *increase with the distance from the plant* according to an exact mathematical law.

This invention was one of a number comprised in my "World-System" of wireless transmission which I undertook to commercialize on my return to New York in 1900. As to the immediate purposes of my enterprise, they were clearly outlined in a technical statement of that period from which I quote:

"The 'World-System' has resulted from a combination of several original discoveries made by the inventor in the course of long continued research and experimentation. It makes possible not only the instantaneous and precise wireless transmission of any kind of signals, messages or characters, to all parts of the world, but also the inter-connection of the existing telegraph, telephone, and other signal stations without any change in their present equipment. By its means, for instance, a telephone subscriber here may call up and talk to any other subscriber on the Globe. An inexpensive receiver, not bigger than a watch, will enable him to listen anywhere, on land or sea, to a speech delivered or music played in some other place, however distant. These examples are cited merely to give an idea of the possibilities of this great scientific advance, which annihilates distance and makes that perfect natural conductor, the Earth, available for all the innumerable purposes which human ingenuity has found for a line-wire. One far-reaching result of this is that any device capable of being operated thru one or more wires (at a distance obviously restricted) can likewise be actuated, without artificial conductors and with the same facility and accuracy, at distances to which there are no limits other than those imposed by the physical dimensions of the Globe. Thus, not only will entirely new fields for commercial exploitation be opened up by this ideal method of transmission but the old ones vastly extended.

"The 'World-System' is based on the application of the following important inventions and discoveries:

"1. *The 'Tesla Transformer.'* This apparatus is in the production of electrical vibrations as revolutionary as gunpowder was in warfare. Currents many times stronger than any ever generated in the usual ways, and sparks over one hundred feet long, have been produced by the inventor with an instrument of this kind.

"2. *The 'Magnifying Transmitter.'* This is Tesla's best invention—a peculiar transformer specially adapted to excite the Earth, which is in the transmission of electrical energy what the telescope is in astronomical observation. By the use of this marvelous device he has already set up electrical movements of greater intensity than those of lightning and passed a current, sufficient to light more than two hundred incandescent lamps, around the Globe.

"3. *The 'Tesla Wireless System.'* This system comprises a number of improvements and is the only means known for transmitting economically electrical energy to a distance without wires. Careful tests and measurements in connection with an experimental station of great activity, erected by the inventor in Colorado, have demonstrated that power in any desired amount can be conveyed, clear across the Globe if necessary, with a loss not exceeding a few per cent.

"4. *The 'Art of Individualization.'* This invention of Tesla is to primitive 'tuning' what refined language is to unarticulated expression. It makes possible the transmission of signals or messages absolutely secret and exclusive both in the active and passive aspect, that is, non-interfering as well as non-interferable. Each signal is like an individual of unmistakable identity and there is virtually no limit to the number of stations or instruments which can be simultaneously operated without the slightest mutual disturbance.

"5. *The terrestial Stationary Waves."* This wonderful discovery, popularly explained, means that the Earth is responsive to electrical vibrations of definite pitch just as a tuning fork to certain waves of sound. These particular electrical vibrations, capable of powerfully exciting the Globe, lend themselves to innumerable uses of great importance commercially and in many other respects.

"The first 'World-System' power plant can be put in operation in nine months. With this power plant it will be practicable to attain electrical activities up to ten million horsepower and it is designed to serve for as many technical achievements as are possible without due expense. Among these the following may be mentioned:

"(1) The inter-connection of the existing telegraph exchanges or offices all over the world;

"(2) The establishment of a secret and non-interferable government telegraph service;

"(3) The inter-connection of all the present telephone exchanges or offices on the Globe;

"(4) The universal distribution of general news, by telegraph or telephone, in connection with the Press;

"(5) The establishment of such a 'World-System' of intelligence transmission for exclusive private use;

"(6) The inter-connection and operation of all stock tickers of the world;

"(7) The establishment of a 'World-System' of musical distribution, etc.;

"(8) The universal registration of time by cheap clocks indicating the hour with astronomical precision and requiring no attention whatever;

"(9) The world transmission of typed or hand-written characters, letters, checks, etc.;

"(10) The establishment of a universal marine service enabling the navigators of all ships to steer perfectly without compass, to determine the exact location, hour and speed, to prevent collisions and disasters, etc.;

"(11) The inauguration of a system of world-printing on land and sea;

"(12) The world reproduction of photographic pictures and all kinds of drawings or records."

I also proposed to make demonstrations in the wireless transmission of power on a small scale but sufficient to carry conviction. Besides these I referred to other and incomparably more important applications of my discoveries which will be disclosed at some future date.

A plant was built on Long Island with a tower 187 feet high, having a spherical terminal about 68 feet in diameter. These dimensions were adequate for the transmission of virtually any amount of energy. Originally only from 200 to 300 K.W. were provided but I intended to employ later several thousand horsepower. The transmitter was to emit a wave-complex of special characteristics and I had devised a unique method of telephonic control of any amount of energy.

The tower was destroyed two years ago but my projects are being developed and another one, improved in some features, will be constructed. On this occasion I would contradict the widely circulated report that the structure was demolished by the Government which owing to war conditions, might have created prejudice in the minds of those who may not know that the papers, which thirty years ago conferred upon me the honor of American citizenship, are always kept in a safe, while my orders, diplomas, degrees, gold medals and other distinctions are packed away in old trunks. If this report had a foundation I would have been refunded a large sum of money which I expended in the construction of the tower. On the contrary it was in the interest of the Government to preserve it, particularly as it would have made possible—to mention just one valuable result—the location of a submarine in any part of the world. My plant, services, and all my improvements have always been at the disposal of the officials and ever since the outbreak of the European conflict I have been working at a sacrifice on several inventions of mine relating to aerial navigation, ship propulsion and wireless transmission which are of the greatest importance to the country. Those who are well informed know that my ideas have revolutionized the industries of the United States and I am not aware that there lives an inventor who has been, in this respect, as fortunate as myself especially as regards the use of his improvements in the war. I have refrained from publicly expressing myself on this subject before as it seemed improper to dwell on personal matters while all the world was in dire trouble. I would add further, in view of various rumors which have reached me, that Mr. J. Pierpont Morgan did not interest himself with me in a business way but in the same large spirit in which he has assisted many other pioneers. He carried out his generous promise to the letter and it would have been most unreasonable to expect from him anything more. He had the highest regard for my attainments and gave me every evidence of his complete faith in my ability to ultimately achieve what I had set out to do. I am unwilling to accord to some small-minded and jealous individuals the satisfaction of having thwarted my efforts. These men are to me nothing more than microbes of a nasty disease. My project was retarded by laws of nature. The world was not prepared for it. It was too far ahead of time. But the same laws will prevail in the end and make it a triumphal success.

Tesla Bulbs

(*Continued from page 134*)

scription of the phenomenon, as seen in a bulb without conducting electrode. It is observed under the following conditions:

"When the globe L (Figs. 1 and 2) is exhausted to a very high degree, generally the bulb is not excited upon connecting the wire *w* (Fig. 1), or the tinfoil coating of the bulb (Fig. 2) to the terminal of the induction coil. To excite it, it is usually sufficient to grasp the globe L with the hand. An intense phosphorescence then spreads at first over the globe, but soon gives place to *a white, misty light.* Shortly afterward one may notice that the luminosity is unevenly distributed in the globe, and after passing the current for some time the bulb appears as in Fig. 4. From this stage the phenomenon will gradually pass to that indicated in Fig. 5, after some minutes, hours, days or weeks, according as the bulb is worked. Warming the bulb or increasing the potential hastens the transit.

"When the brush assumes the form indicated in Fig. 5, it may be brought to a state of *extreme sensitiveness to electrostatic and magnetic influence.* The bulb hanging straight down from a wire, and all objects being remote from it, *the approach of the observer at a few paces from the bulb will cause the brush to fly to the opposite side, and if he walks around the bulb it will always keep on the opposite side.* It may begin to spin aronnd the terminal long before it reaches the sensitive stage. *When it begins to turn around, principally, but also before, it is affected by a magnet,* and at a certain stage it is susceptible to magnetic influence to an astonishing degree. A small permanent magnet, with its poles at a distance of no more than two centimeters, will affect it visibly at a distance of two meters, slowing down or accelerating the rotation according to how it is held relatively to the brush. I think I have observed that at the stage when it is most sensitive to magnetic, it is not most sensitive to electrostatic, influence.

"When the bulb hangs with the globe L down, the rotation is always clockwise. In the southern hemisphere it would occur in the opposite direction, and on the equator the brush should not turn at all. The rotation may be reversed by a magnet kept at some distance. The brush rotates best, seemingly, when it is at right angles to the lines of force of the earth. It very likely rotates, when at its maximum speed, in synchronism with the alternations, say, 10,000 times a second. The rotation can be slowed down or accelerated by the approach or receding of the observer, or any conducting body, but it cannot be reversed by putting the bulb in any position. When it is in the state of the highest sensitiveness and the potential or frequency be varied, the sensitiveness is rapidly diminished. Changing either of these but little will generally stop the rotation. The sensitiveness is likewise affected by the variations of temperature. To attain great sensitiveness it is necessary to have the small sphere *s* in the center of the globe *L*, as otherwise the electrostatic action of the glass of the globe will tend to stop the rotation. The sphere *s* should be small and of uniform thickness; any dissymmetry of course has the effect to diminish the sensitiveness.

"The fact that the brush rotates in a definite direction in a permanent magnetic field seems to show that in alternating currents of very high frequency the positive and negative impulses are *not* equal, but that one always preponderates over the other.

"Of course, this rotation in one direction may be due to the action of the two elements of the same current upon each other, or to the action of the field produced by one of the elements upon the other, as in a

series motor, without necessarily one impulse being stronger than the other. The fact that the brush turns, as far as I could observe, in any position, would account for this theory. In such case it would turn at any point of the earth's surface. But, on the other hand, it is then hard to explain why a permanent magnet should reverse the rotation, and one must assume the preponderance of impulses of one kind.

"As to the causes of the formation of the brush or stream, I think it is due to the electrostatic action of the globe and the dissymmetry of the parts. If the small bulb *s* and the globe L were perfect concentric spheres, and the glass thruout of the same thickness and quality, I think the brush would not form, as the tendency to pass would be equal on all sides. That the formation of the stream is due to an irregularity is apparent from the fact that it has the tendency to remain in one position, and rotation occurs most generally only when it is brought out of this position by electrostatic or magnetic influence. When in an extremely sensitive state it rests in one position, and most curious experiments may be performed with it. For instance, the experimenter may, by selecting a proper position, approach the hand at a certain considerable distance to the bulb, and he may cause the brush to pass off by merely stiffening the muscles of the arm. When it begins to rotate slowly, and the hands are held at a proper distance, it is impossible to make even the slightest motion without producing a visible effect upon the brush. A metal plate connected to the other terminal of the coil affects it at a great distance, slowing down the rotation often to one turn a second.

"I am firmly convinced that such a brush, when we learn how to produce it properly, will prove a valuable aid in the investigation of the nature of the forces acting in an electrostatic or magnetic field. If there is any motion which is measurable going on in the space, such a brush ought to reveal it. It is, so to speak, a beam of light—frictionless, devoid of inertia.

"I think that it may find practical applications in telegraphy. With such a brush it would be possible to send dispatches across the Atlantic, for instance, with any speed, since its sensitiveness may be so great that the slightest changes will affect it. If it were possible to make the stream more intense and very narrow, its deflections could be easily photographed.

"I have been interested to find whether there is a rotation of the stream itself, or whether there is simply a stress traveling around the bulb. For this purpose I mounted a light mica fan so that its vanes were in the path of the brush. If the stream itself was rotating the fan would be spun around. I could produce no distinct rotation of the fan, altho I tried the experiment repeatedly; but as the fan exerted a noticeable influence on the stream, and the apparent rotation of the latter was, in this case, never quite satisfactory, the experiment did not appear to be conclusive.

"I have been unable to produce the phenomenon with the disruptive discharge coil, altho every other form of these phenomena can be well produced by it—many, in fact, much better than with coils operated from an alternator.

"It may be possible to produce the brush by impulses of one direction, or even by a steady potential, in which case it would be still more sensitive to magnetic influence."

Fig. 6 shows a practical application of the Tesla bulb. The bulb itself, as will be seen, is excited by means of a Tesla high frequency alternator which, in turn, is connected to the primary of a transformer. The secondary of the transformer is grounded at one end, while the other end of the transformer connects with the Tesla bulb.

Dr. Tesla, in an interview, stated that

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Tesla Bulbs

(*Continued from page* 180)

the best way to use the bulb for such experiments is when the shaft of light is in the position as shown in Figs. 5 and 6, at rest, but in a state of equilibrium inconceivably delicate. This is fully described above in Dr. Tesla's lecture. The inventor states that in such a condition, the shaft of light is marvelously sensitive to magnetic disturbances. Dr. Tesla informs us that a toy permanent horseshoe magnet not longer than ½" and with its poles ⅛" apart could with ease throw the shaft of light out of its normal direction across the whole room. In our illustration, an electromagnet is shown a few inches away from light ray, and we can imagine a slot in a screen in such a way that normally no light falls thru it. If, however, very faint radio-telegraphic impulses surge thru the electromagnet, the light ray will immediately become displaced, and will fall into the slot. Inasmuch as this shaft of light has no inertia, it will follow exactly the dot and dash impulses surging thru the electromagnet, no matter how rapidly they take place. They can then either be read off by the eye, or if desired, can be registered upon a fast moving film. This method will, of course, only be used where the transmission is made at high speed, and where it would be impossible for an operator at the receiving end to follow the dots and dashes with the eye.

The method shown by us in Fig. 6, of course, represents only one. Many others can undoubtedly be evolved to use the Tesla bulb to advantage.

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC., REQUIRED BY THE ACT OF CONGRESS OF AUGUST 24, 1912, of Electrical Experimenter, published monthly at New York, N. Y., for April 1, 1919.

State of New York, County of New York—ss.

Before me, a Notary Public in and for the State and county aforesaid, personally appeared Hugo Gernsback, who, having been duly sworn according to law, deposes and says that he is the Editor of the Electrical Experimenter, and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management, etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, embodied in section 443, Postal Laws and Regulations:

1. That the names and addresses of the publisher, editor, managing editor, and business manager are: Publisher, The Experimenter Publishing Co., 233 Fulton Street, New York City; Editor, Hugo Gernsback, 233 Fulton Street, New York City; Managing Editor, Harry Winfield Secor, 233 Fulton Street, New York City; Business Manager, Hugo Gernsback, 233 Fulton Street, New York City.

2. That the owners are: Experimenter Publishing Co., 233 Fulton Street, New York City; Hugo Gernsback, 233 Fulton Street, New York City; Sidney Gernsback, 233 Fulton Street, New York City; Mrs. K. Hymes, 233 Fulton Street, New York City; Harry Winfield Secor, 233 Fulton Street, New York City.

3. That the known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities are: None.

4. That the two paragraphs next above, giving the names of the owners, stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company but, also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has any interest direct or indirect in the said stock, bonds, or other securities than as so stated by him.

5. That the average number of copies of each issue of this publication sold or distributed, through the mails or otherwise, to paid subscribers during the six months preceding the date shown above is —(Required only of daily publications.)

(SEAL) H. GERNSBACK.

Sworn to and subscribed before me this 4th day of April, 1919.

BEATRICE K. OWEN.

(My commission expires March 30, 1921.)

Electrical Oscillators

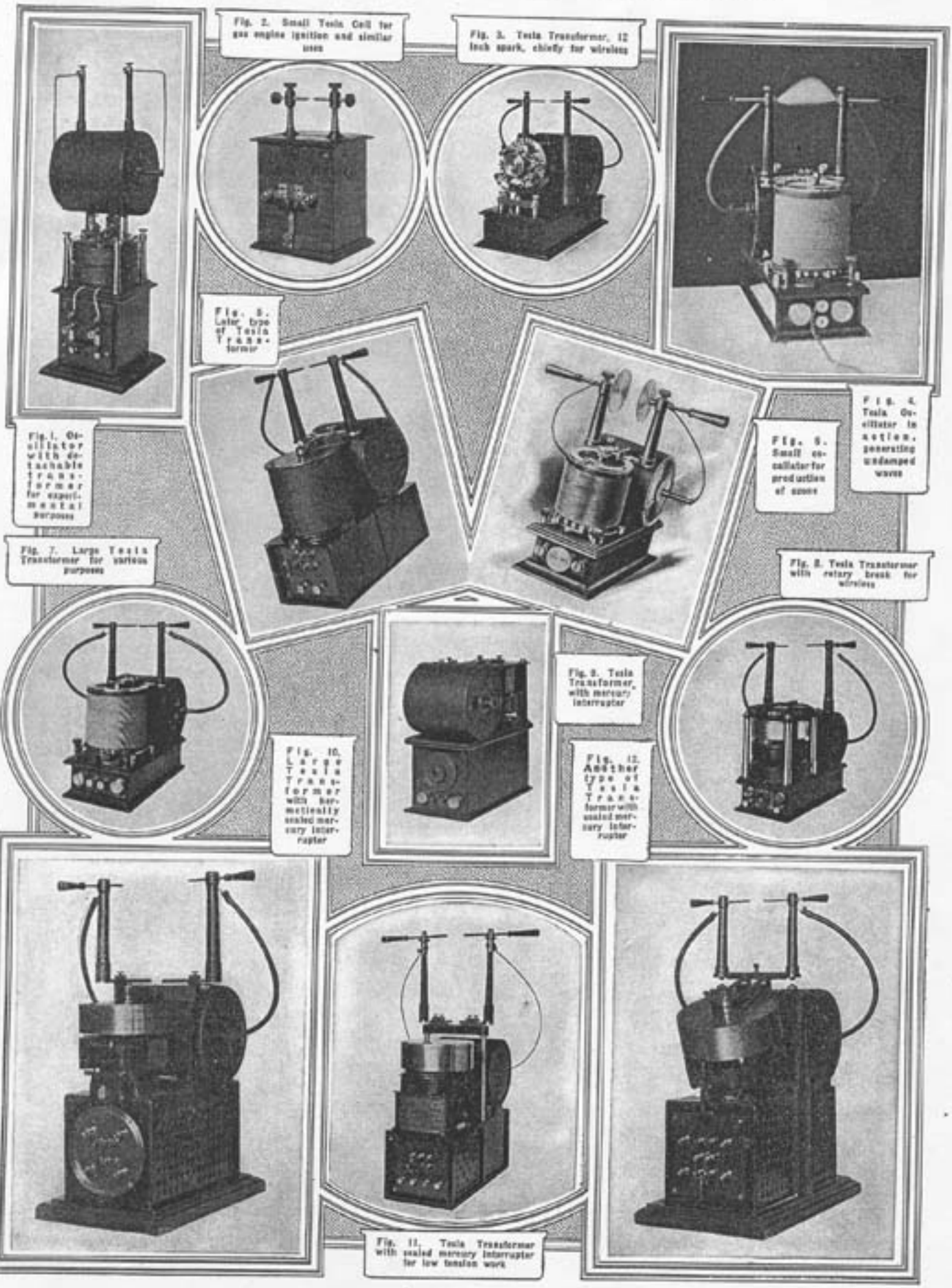


Fig. 1. Oscillator with detachable transformer for experimental purposes

Fig. 2. Small Tesla Coil for gas engine ignition and similar uses

Fig. 3. Tesla Transformer, 12 inch spark, chiefly for wireless

Fig. 4. Tesla Oscillator in action, generating undamped waves

Fig. 5. Small oscillator for production of ozone

Fig. 6. Later type of Tesla Transformer

Fig. 7. Large Tesla Transformer for various purposes

Fig. 8. Tesla Transformer with rotary break for wireless

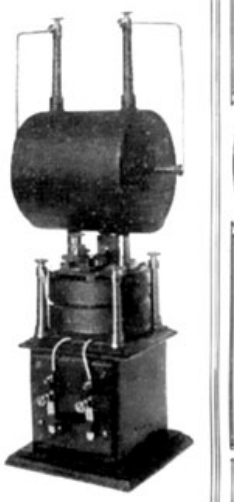
Fig. 9. Tesla Transformer, with mercury interrupter

Fig. 10. Large Tesla Transformer with hermetically sealed mercury interrupter

Fig. 11. Tesla Transformer with sealed mercury interrupter for low tension work

Fig. 12. Another type of Tesla Transformer with sealed mercury interrupter

Electrical Oscillators



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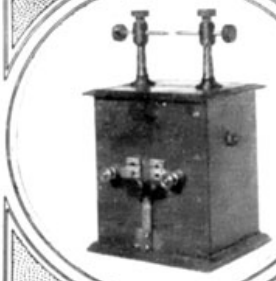
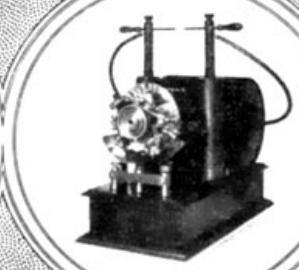
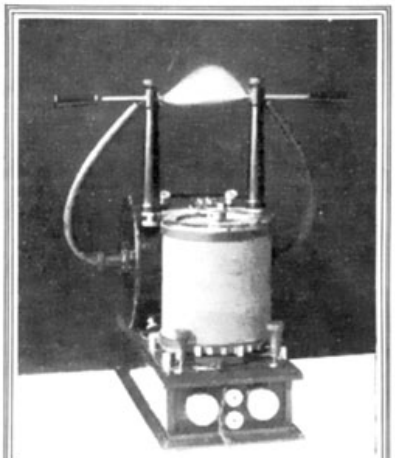


Fig. 3. Tesla Transformer, 12 inch spark, chiefly for wireless





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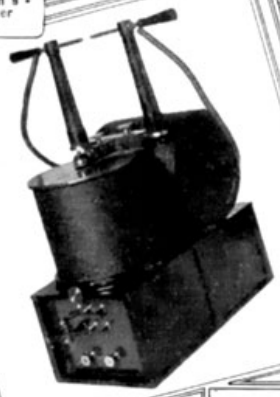

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Fig. 9. Tesla Transformer with mercury interrupter

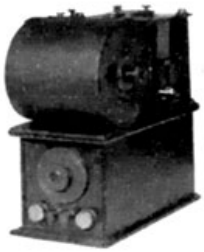

Fig. 10. Large Tesla Transformer with hermetically sealed mercury interrupter

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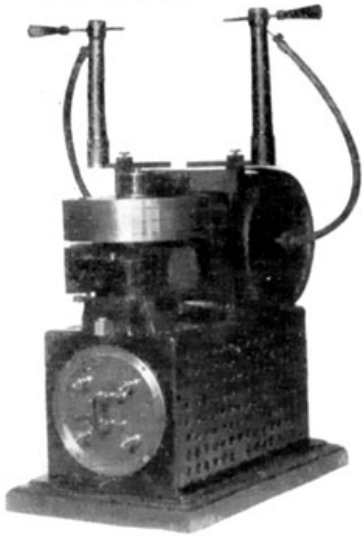


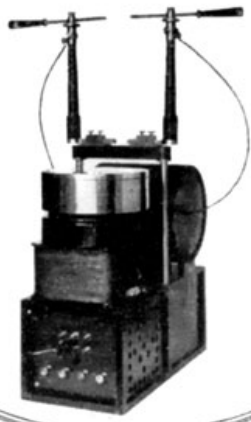
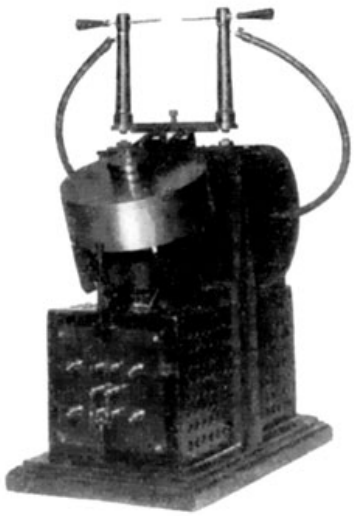


Fig. 11. Tesla Transformer with sealed mercury interrupter for low tension work



Electrical Oscillators

By NIKOLA TESLA

FEW fields have been opened up the exploration of which has proved as fruitful as that of high frequency currents. Their singular properties and the spectacular character of the phenomena they presented immediately commanded universal attention. Scientific men became interested in their investigation, engineers were attracted by

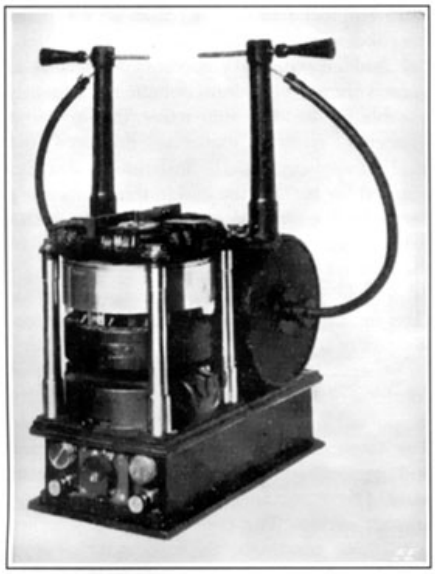


Fig. 13—Tesla Oscillator with Magnetically Controlled, Sealed Mercury Interrupter.

their commercial possibilities, and physicians recog-nized in them a long-sought means for effective treatment of bodily ills. Since the publication of my first researches in 1891, hundreds of volumes have been written on the subject and many invaluable Jesuits obtained thru the medium of this new agency. Yet, the art is only in its infancy and the future has incomparably bigger things in store.

From the very beginning I felt the necessity of producing efficient apparatus to meet a rapidly growing demand and during the eight years succeeding my original announcements I developed not less than fifty types of these transform-

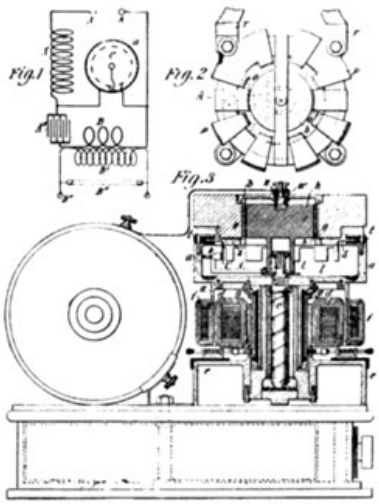


Fig. 14—Electrical Oscillator, Illustrated in Fig. 13, Showing Details and Circuit Connections.

MR. TESLA makes a very important contribution to the electrical arts with this article.

The pioneer of all high frequency apparatus divulges much that is new and startling in these pages. Few people realize the enormous value of Mr. Tesla's machines and the many different important uses to which they can be applied in our everyday lives. New and startling uses are being found every year for these machines.

It is characteristic of Mr. Tesla that he has developed and actually built an astounding variation of these machines, and we regret that we can publish only a very few of the more important models.

Most of the Tesla coils shown have never been publisht before. —EDITOR.

ers or electrical oscillators, each complete in every detail and refined to such a degree that I could not materially improve any one of them today. Had I been guided by practical considerations I might have built up an immense and profitable business, incidentally rendering important services to the world. But the force of circumstances and the ever enlarging vista of greater achievements turned my efforts in other directions. And so it comes that instruments will shortly be placed on the market which, oddly enough, were perfected twenty years ago!

These oscillators are expressly intended to operate on direct and alternating lighting circuits and to generate damped and undamped oscillations or currents of any frequency, volume and tension within the widest limits. They are compact, self-contained, require no care for long periods of time and will be found very convenient and useful for various purposes as, wireless telegraphy and telephony; conversion of electrical energy; formation of chemical compounds thru fusion and combination; synthesis of gases; manufacture of ozone; lighting; welding; municipal, hospital, and domestic sanitation and sterilization, and numerous other applications in scientific laboratories and industrial institutions. While these transformers have never been described before, the general principles underlying them were fully set forth in my publisht articles and patents, more particularly those of September 22, 1896, and it is thought, therefore, that the appended photographs of a few types, together with a short explanation, will convey all the information that may be desired.

SPECIAL NOTICE

Last month we announced another special feature article by Mr Tesla, which altho made in good faith by us was not authorized by him. Due to very important duties of Mr. Tesla, it was impossible for him to furnish his historical article this month, so the special feature article pubiisht on this page takes its place. An important historical article will appear in the August issue. —Editor.

The essential parts of such an oscillator are: a condenser, a self-induction coil for charging the same to a high potential, a circuit controller, and a transformer which is energized by the oscillatory discharges of the condenser. There are at

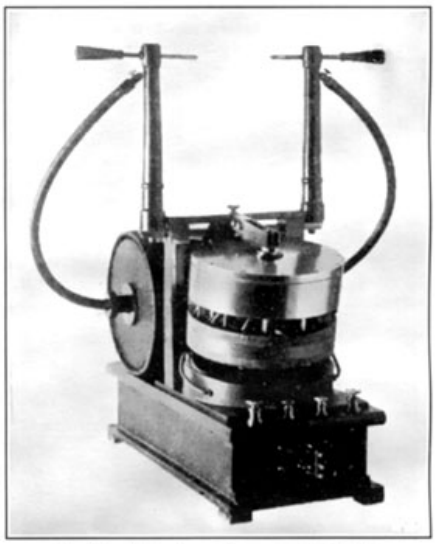


Fig. 15—Tesla Transformer with Gravity Controlled, Sealed Mercury Interrupter.

least three, but usually four, five or six, circuits in tune and the regulation is effected in several ways, most frequently merely by means of an adjusting screw. Under favorable conditions an efficiency as high as 85% is attainable, that is to say, that percentage of the energy supplied can be recovered in the secondary of the transformer. While the chief virtue of this kind of apparatus is obviously due to the wonderful powers of the condenser, special qualities result from concatenation of circuits under observance of accurate harmonic relations, and minimization of frictional and other losses which has been one of the principal objects of the design.

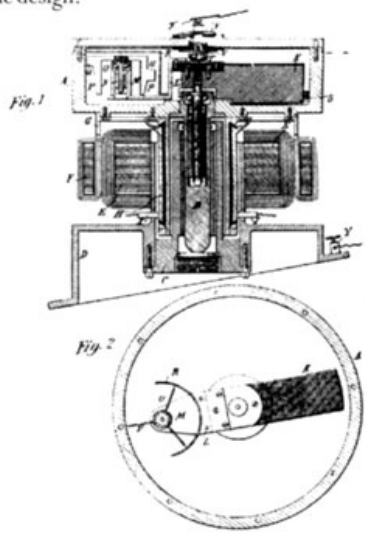


Fig. 16—Electrical Oscillator, Illustrated in Fig. 15, Showing Details of Motor and Break Mechanism.

Broadly, the instruments can be divided into two classes: one in which the circuit controller comprises solid contacts, and the other in which the make and break is effected by mercury. Figures 1 to 8, inclusive, belong to the first, and the remaining ones to the second class. The former are capable of an appreciably higher efficiency on account of the fact that the losses involved in the make and break are reduced to the minimum and the resistance component of the damping factor is very small. The latter are preferable for purposes requiring larger output and a great number of breaks per second. The operation of the motor and circuit controller of course consumes a certain amount of energy which, however, is the less significant the larger the capacity of the machine.

In Fig. 1 is shown one of the earliest forms of oscillator constructed for experimental purposes. The condenser is contained in a square box of mahogany upon which is mounted the self-induction or charging coil wound, as will be noted, in two sections connected in multiple or. series according to whether the tension of the supply circuit is 110 or 220 volts. From the box protrude four brass columns carrying a plate with the spring contacts and adjusting screws as well as two massive terminals for the reception of the primary of the transformer. Two of the columns serve as condenser connections while the other pair is employed to join the binding posts of the switch in front to the self-inductance and condenser. The primary coil consists of a few turns of copper ribbon to the ends of which are soldered short rods fitting into the, terminals referred to. The secondary is made in two parts, wound in a manner to reduce as much as possible the distributed capacity and at the same time enable the coil to withstand; a very high pressure between its terminate at the center, which are connected to binding posts on two rubber columns projecting from the primary. The circuit connections may be slightly varied but ordinarily they are as diagrammatically illustrated in the Electrical Experimenter for May on page 89, relating to my oscillation transformer photograph of which appeared on page 16 of the same number. The operation is as follows: When the switch is thrown on, the current from the supply circuit rushes thru the self-induction coil, magnetizing the iron core within and separating the contacts of the controller. The high tension induced current then charges the condenser and upon closure of the contacts the accumulated energy is released thru the primary, giving rise to a long series of oscillations which excite the tuned secondary circuit.

This device has proved highly serviceable in carrying on laboratory experiments of all kinds. For instance, in studying phenomena of impedance, the transformer was removed and a bent copper bar inserted in the terminals. The latter was often replaced by a large circular loop to exhibit inductive effects at a distance or to excite resonant circuits used in various investigations and measurements. A transformer suitable for any desired performance could be readily improvised and attached to the terminals and in this way much time and labor was saved. Contrary to what might be naturally expected, little trouble was experienced with the contacts, altho the currents thru them were heavy, namely, proper conditions of resonance existing, the great flow occurs only when the circuit is closed and no destructive arcs can develop. Originally I employed platinum and iridium tips but later replaced them by some of meteorite and finally of tungsten. The last have given the best satisfaction, permitting working for hours and days without interruption.

Fig. 2 illustrates a small oscillator designed for certain specific uses. The underlying idea was to attain great activities during minute intervals of time each succeeded by a comparatively long period of inaction. With this object a large self-induction and a quick-acting break were employed owing to which arrangement the condenser was charged to a very high potential. Sudden secondary currents and sparks of great volume were thus obtained, eminently suitable for welding thin wires, flashing lamp filaments, igniting explosive mixtures and kindred applications. The instrument was also adapted for battery use and in this form was a very effective igniter for gas engines on which a patent bearing number 609,250 was granted to me August 16, 1898.

Fig. 3 represents a large oscillator of the first class intended for wireless experiments, production of Röntgen rays and scientific research 'in general. It comprises a box containing two condensers of the same capacity on which are supported the charging coil and transformer. The automatic circuit controller, hand switch and connecting posts are mounted on the front plate of the inductance spool as is also one of the contact springs. The condenser box is equipt with three terminals, the two external ones serving merely for connection while the middle one carries a contact bar with a screw for regulating the interval during which the circuit is closed. The. vibrating spring itself, the sole function of which is to cause periodic interruptions, can be adjusted in its strength as well as distance from the iron core in the center of the charging coil by four screws visible on the top plate so that any desired conditions of mechanical control might be secured. The primary coil of the transformer is of copper sheet and taps are made at suitable points for the purpose of varying, at will, the number of turns. As in Fig. 1 the inductance coil is wound in. two sections to adapt the instrument both to 110 and 220 volt circuits and several secondaries were provided to. suit the various wave lengths of the primary. The output was approximately 500 watt with damped waves of about 50,000 cycles per second. For short periods of time undamped oscillations were produced in screwing the vibrating spring tight against the iron core and separating the contacts by the adjusting screw *which also performed the function of a hey*. With this oscillator I made a number of important observations and it was one of the machines exhibited at a lecture before the New York Academy of Sciences in 1897.

Fig. 4 is a photograph of a type of transformer in every respect similar to the one illustrated in the May, 1919, issue of the ELECTRICAL EXPERIMENTER to which reference has already been made. It contains the identical essential parts, disposed in like manner, but was specially designed for use on supply circuits of higher tension, from 220 to 500 volts or more. The usual adjustments are made in

setting the contact spring and shifting the iron core within the inductance coil up and down by means of two screws. In order to prevent injury thru a short-circuit, fuses—are inserted in the lines. The instrument was photographed in action, generating undamped oscillations from a 220 volt lighting circuit.

Fig. 5 shows a later form of transformer principally intended to replace Rhumkorf coils. In this instance a primary is employed, having a much greater number of turns and the secondary is closely linked with the same. The currents developed in the latter, having a tension of from 10,000 to 30,000 volts, are used to charge condensers and operate an independent high frequency coil as customary. The controlling mechanism is of somewhat different construction but the core and contact spring are both adjustable as before.

Fig. 6 is a small instrument of this type, particularly intended for ozone production or sterilization. It is remarkably efficient for its size and can be connected either to a 110 or 220 volt circuit, direct or alternating, preferably the former.

Fig. 17. Tesla Transformer With Adjustable Mercury Controller.

In Fig. 7 is shown a photograph of a larger transformer of this kind. The construction and disposition of the parts is as before but there are two condensers in the box, one of which is connected in the circuit as in the previous cases, while the other is in shunt to the primary coil. In this manner currents of great volume are produced in the latter and the secondary effects are accordingly magnified. The introduction of an additional tuned circuit secures also other advantages but the adjustments are rendered more difficult and for this reason it is desirable to use such an instrument in the production of currents of a definite and unchanging frequency.

Fig. 8 illustrates a transformer with rotary break. There are two condensers of the same capacity in the box which can be connected in series or multiple. The charging inductances are in the form of two long spools upon which are supported the secondary terminals. A small direct current motor, the speed of which can be varied within wide limits, is employed to drive a specially constructed make and break. In other features the oscillator is like the one illustrated in Fig. 3 and its operation will be readily understood from the foregoing. This transformer was used in my wireless experiments and frequently also for lighting the laboratory by my vacuum tubes and was likewise exhibited at my lecture before the New York Academy of Sciences above mentioned.

Coming now to machines of the second class, Fig. 9 shows an oscillatory transformer comprising a condenser and charging inductance enclosed in a box, a transformer and a mercury circuit controller, the latter being of a construction described for the first time in my patent No. 609,251 of August 16, 1898. It consists of a motor driven hollow pulley containing a small quantity of mercury which is thrown outwardly against the walls of the vessel by centrifugal force and entrains a contact wheel which periodically closes and opens the condenser circuit. By means of adjusting screws above the pulley, the depth of immersion of the vanes and consequently, also, the duration of each contact can be varied at desire and thus the intensity of the effects and their character controlled. This form of break has given thoro satisfaction, working continuously with currents of from 20 to 25 amperes. The number of interruptions is usually from 500 to 1,000 per second but higher frequencies are practicable. The space occupied is about 10" x 8" x 10" and the output approximately " K.W.

In the transformer just described the break is exposed to the atmosphere and a slow oxidation of the mercury takes place. This disadvantage is overcome in the instrument shown in Fig. 10, which consists of a perforated metal box containing the condenser and charging inductance and carrying on the top a motor driving the break, and a transformer. The mercury break is of a kind to be described and. operates on the principle of a jet which establishes, intermittently, contact with a: rotating wheel in the interior of the pulley. The stationary parts are supported in the vessel on a bar passing thru the long hollow shaft of the motor and a mercury seal is employed to effect hermetic closure of the chamber enclosing the circuit controller. The current is led into the interior of the pulley thru two sliding rings on the top which are in series with the condenser and primary. The exclusion of the oxygen is a decided improvement, the deterioration of the metal and attendant trouble being eliminated and perfect working conditions continuously maintained.

Fig. 11 is a photograph of a similar oscillator with hermetically inclosed mercury break. In this machine the stationary parts of the interrupter in the interior of the pulley were supported on a tube thru which was led an insulated wire connecting to one terminal of the break while the other was in contact with the vessel. The sliding rings were, in this manner, avoided and the construction simplified. The instrument was designed for oscillations of lower tension and frequency requiring primary currents of comparatively smaller amperage and was used to excite other resonant circuits.

Fig. 12 shows an improved form of oscillator of the kind described in Fig. 10, in which the supporting bar thru the hollow motor shaft was

done away with, the device pumping the mercury being kept in position by gravity, as will be more fully explained with reference to another figure. Both the capacity of the condenser and primary turns were made variable with the view of producing oscillations of several frequencies.

Fig. 13 is a photographic view of another form of oscillatory transformer with hermetically sealed mercury interrupter, and Fig. 14 diagrams showing the circuit connections and arrangement of parts reproduced from my patent, No. 609,245, of August 16, 1898, describing this particular device. The condenser, inductance, transformer and circuit controller are disposed as before, but the latter is of different construction, which will be clear from an inspection of Fig. 14. The hollow pulley *a* is secured to a shaft *c* which is mounted in a vertical bearing passing thru the stationary field magnet *d* of the motor. In the interior of the vessel is supported, on frictionless bearings, a body *h* of magnetic material which is surrounded by a dome *b* in the center of a laminated iron ring, with pole pieces *oo* wound with energizing coils *p*. The ring is supported on four columns and, when magnetized, keeps the body *h* in position while the pulley is rotated. The latter is of steel, but the dome is preferably made of German silver burnt black by acid or nickeled. The body *h* carries a short tube *k* bent, as indicated, to catch the fluid as it is whirled around, and project it against the teeth of a wheel fastened to the pulley. This wheel is insulated and contact from it to the external circuit is established, thru a mercury cup. As the pulley is rapidly rotated a jet of the fluid is thrown against the wheel, *thus making and breaking contact about 1,000 times per second*. The instrument works silently and, owing to the absence of all deteriorating agents, keeps continually clean and in perfect condition. The number of interruptions per second may be much greater, however, so as to make the currents suitable for wireless telephony and like purposes.

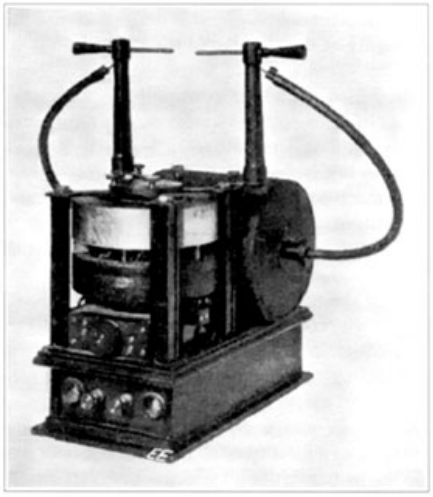


Fig. 18, Tesla Transformer With Mercury Jet Interrupter.

A modified form of oscillator is represented in Figs. 15 and 16, the former being a photographic view and the latter a diagrammatic illustration showing the arrangement of the interior parts of the controller. In this instance the shaft *b* carrying the vessel *a* is hollow and supports, in frictionless bearings, a spindle *j* to which is fastened a weight *k*. Insulated from the latter, but mechanically fixt to it, is a curved arm L upon which is supported, freely rotatable, a break-wheel with projections QQ. The wheel is in electrical connection with the external circuit thru a mercury cup and an insulated plug supported from the top of the pulley. Owing to the inclined position of the motor the weight *k* keeps the break-wheel in place by the force of gravity and as the pulley is rotated the circuit, including the condenser and primary coil of the transformer, is rapidly made and broken.

Fig. 17 shows a similar instrument in which, however, the make and break device is a jet of mercury impinging against an insulated toothed wheel carried on an insulated stud in the center of the cover of the pulley as shown. Connection to the condenser circuit is made by brushes bearing on this plug.

Fig. 18 is a photograph of another transformer with a mercury circuit controller of the wheel type, modified in some features on which it is unnecessary to dwell.

These are but a few of the oscillatory transformers I have perfected and constitute only a small part of my high frequency apparatus of which I hope to give a full description, when I shall have freed myself of pressing duties, at some future date.

The April

American

Magazine

25 Cents

DRAWN BY C. F. UNDERWOOD

The Home You Can Live In On Your Income —

See page 42

Making Your Imagination Work for You

An interview with Nikola Tesla, great inventor, who tells the romantic story of his life. He also describes a method of work he has evolved, which will be of use to any imaginative man, whether he is an inventor, business man, or artist

By M. K. Wisehart

THERE were two inventions to my credit before I was six years old. The first was a hook for catching bullfrogs. A boy in our little village of Smiljan, Jugo-Slavia, had received a present of a hook and fishing tackle. This made a great stir among my playmates, and the next morning they all started out to catch frogs; but I was left alone because I'd had a quarrel with the boy who owned the tackle.

I never had seen a hook, and I imagined it to be a wonderful something with mysterious qualities; but, prompted by necessity, I got hold of a piece of soft iron wire, bent it, and sharpened it by means of two stones. Then I attached it to a strong string, cut a rod, gathered bait, and went to the brook, where the frogs were innumerable.

In vain I tried to capture the frogs in the water; and I was humiliated to think what a big catch my playmates would bring home with their fine tackle. But at last I dangled my empty hook in front of a frog sitting on a stump, and I can see now in my mind's eye what happened as vividly as though it were yesterday.

First, the frog collapsed, then his eyes bulged, and he swelled to twice his normal size, made a vicious snap at the hook—and I pulled him in. This method proved so infallible that I went home with a fine catch, whereas my playmates caught none. To this day I consider my frog-hook invention quite remarkable and very ambitious. It involved the invention both of an *apparatus* and a *method*. I may have been anticipated in the former, but I like to think that the latter was original.

My second invention was prompted by the very same desire that guides me in all I do to-day, the desire to harness the forces of nature to the service of man. This I did, at that time, through the medium of May bugs, or June bugs as we call them in America. These bugs were such a pest in our neighborhood that sometimes the sheer weight of their bodies brought down branches of trees.

Four of the bugs I attached to a cross-piece of wood, which was arranged so as to rotate on a thin spindle. The motion of the spindle was transmitted to a large disk, and in this way I derived my power; for, once started going, the May bugs never knew when to stop; the hotter it was, the harder they worked. This invention gave me complete satisfaction until one day I saw the son of a retired officer of the Austrian army eating May bugs, and seeming to enjoy them. I never played with the bugs after that, and to this day I shrink from touching any kind of insect.

The memories of my youth and even of earliest childhood are very vivid, and it seems to me that my character began to develop a little sooner than is the case with most people. As a very small boy I was weak and vacillating, and made many childish resolves, only to break them. But when I was eight years old I read "The Son of Aba," a Serbian translation of a Hungarian writer, Josika, whose lessons are similar to those of Lew Wallace in Ben Hur. This book awakened my will power. I began to practice self-control, subdued many of my wishes, and resolved to keep every promise I ever made, whether to myself or to anyone else. The members of my family were not long in learning that if I promised a thing I would do it.

Long before I was twenty, I was smoking excessively—fifteen or twenty big black cigars every day. My health was threatened, and my family often tried to get me to promise to stop, but I would not.

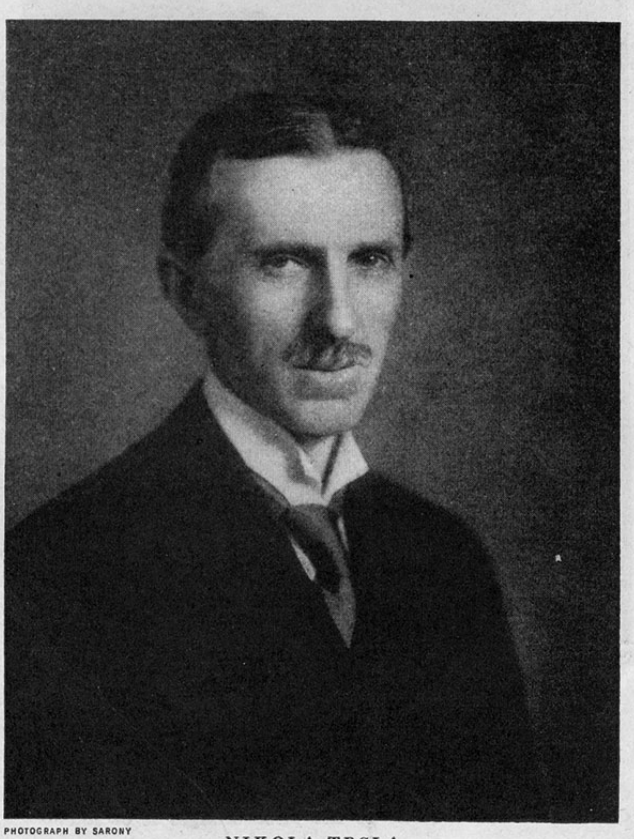
One day I was standing in front of our house, when they told me the doctor had just said that my youngest sister, who had been very ill for some time, was dying. I went up to her room, carrying my lighted cigar, and before kneeling at her bedside I placed the cigar on a little table beside the bed.

"Niko," she said, so faintly that I could hardly hear her, "you are killing yourself with smoking. Promise me you will give it up."

"Yes," I said; "if you will get well, I promise to give up smoking."

"All right, Niko," she said feebly. "I will try."

(*Continued on page 60*)



PHOTOGRAPH BY SARONY

NIKOLA TESLA

Born and educated in what was then Austria-Hungary, Tesla came to this country thirty-seven years ago when he was twenty-seven years old. His first invention, a telephone repeater, has been followed by other enormously valuable contributions to the science of telegraphy and telephony, especially in connection with the system of wireless transmission. He lives in New York City

Making Your Imagination Work for You

(*Continued from page 13*)

She did get well, and I have never smoked since. It was very hard to give it up, but I was determined to keep my promise. Not only did I stop, but I finally destroyed every inclination for what had been such a great satisfaction. In this way I have freed myself of other habits and passions, and so have preserved my health and my zest for life. The satisfaction derived from demonstrating my own strength of will has always meant more to me in the end than the pleasurable habits I gave up. I believe that a man can and should stop any habit he recognizes to be "foolish."

When I was about twenty, I contracted a mania for gambling. We played for very high stakes; and more than one of my companions gambled away the full value of his home. My luck was generally bad, but on one occasion I won everything in sight. Still I was not satisfied, but must go on with the play. I lent my companions money so that we might continue, and before we left the table I had lost all that I had won and was in debt.

MY PARENTS were greatly worried by my gambling habits. My father especially was stern and often expressed his contempt at my wanton waste of time and money. However, I never would promise him to give up gambling, but instead defended myself with a bad philosophy that is very common. I told him that, of course, I could stop whenever I pleased, but that it was not worth while to give up gambling because the pleasure was more to me than the joys of Paradise.

My mother understood human nature better and never chided. She knew that a man cannot be saved from his own foolishness or vice by someone else's efforts or protests, but only by the use of his own will. One afternoon, when I had lost all my money, but still was craving to play, she came to me with a roll of bills in her hand—a large sum of money for those times and conditions—and said, "Here, Niko. Take these. They're all I have. But the sooner you lose everything we own, the better it will be. Then I know you will get over this."

She kissed me.

So blinded was I by my passion that I took the money, gambled the whole night, and lost everything, as usual. It was morning when I emerged from the den, and I went on a long walk through sunlit woods pondering my utter folly. The sight of nature had brought me to my senses, and my mother's act and faith came vividly to mind. Before I left the woods, I had conquered this passion. I went home to my mother and told her I never would gamble again. And there never has been the slightest danger of my breaking the promise.

My father was the son of an officer who served in the army of the Great Napoleon. He himself had received military training, and oddly enough, had subsequently embraced the clerical profession. A philosopher, poet, and writer, he achieved eminence as a preacher because of his learning and eloquence. But it is to my mother, I believe, that I trace my inventiveness. Her father and grandfather originated numerous implements for household and agricultural uses. My mother herself invented and constructed all kinds of tools and devices, and wove the finest designs from thread, spun by herself. I have always thought that my mother would have achieved great things if we had not lived so far from the opportunities of modern life.

Both my father and mother were very eager that I should become a preacher; but I had no leaning in that direction. From the age of ten I had been inventing all sorts of things in my mind: flying machines, a submarine tube for carrying letters and packages under the Atlantic, and means of getting power from the rotation of the planets; all fanciful, but even after I had gone to study at the gymnasium at Carlstadt, Croatia, where I became intensely interested in physics and electricity, my parents still wanted me to become a preacher.

Perhaps, if I had not become very ill, I should have given my promise. But because of overstudy, I had my first serious breakdown in health. Physicians absolutely gave me up. It was an American genius who saved my life.

During my illness I read books by the score from the public library, and one day I was handed a few volumes unlike anything I had ever read, and so interesting that I forgot my hopeless state. My recovery seemed miraculous.

The books I had been reading were the early works of Mark Twain—among them "Tom Sawyer," and "Huckleberry Finn." Twenty-five years later, when I met Mr. Clemens and we formed a lifelong friendship, I told him of this experience and of my belief that I owed my life to his books. I was deeply moved to see tears come to the eyes of this great man of laughter.

AFTER graduating from the Higher *Realschule* at Carlstadt, I went home to my parents, and on the very day of my arrival was stricken with cholera, which was then epidemic in those parts. Again I was near death. My father tried to cheer me with hopeful words.

"Perhaps," I said, "I might get well, if you would let me become an engineer instead of a clergyman."

He promised solemnly that I should go to the best technical institution in the world. This, literally, put new life into me; and, owing partly to my improved state of mind and partly to a wonderful medicine, I recovered. My father kept his word by sending me to the Polytechnic School in Gratz, Styria, one of the oldest institutions of Europe.

All during my first year there I started work at three A. M. and continued until eleven P. M., neither Sundays nor holidays being excepted. Such leisure as I allowed myself I spent in the library. It was during my second year that something happened that has determined the whole course of my life. To make this clear, I must tell you about an early experience.

During my boyhood I had suffered from a peculiar affliction due to the appearance of images, which were often accompanied by strong flashes of light. When a word was spoken, the image of the object designated would present itself so vividly to my vision that I could not tell whether what I saw was real or not. If I had witnessed a funeral, or perhaps come close to some wounded animal while on a hunting trip, then inevitably in the stillness of night a vivid picture of the scene would thrust itself before my eyes and persist, despite all my efforts to banish it. Even though I reached out and passed my hand through it, the image would remain fixed in space.

IN TRYING to free myself from these tormenting appearances, I tried to concentrate my mind on some peaceful, quieting scene I had witnessed. This would give me momentary relief; but when I had done it two or three times the remedy would begin to lose its force. Then I began to take mental excursions beyond the small world of my actual knowledge. Day and night, in imagination, I went on journeys—saw new places, cities, countries, and all the time I tried very hard to make these imaginary things very sharp and clear in my mind. I imagined myself living in countries I never had seen, and I made imaginary friends, who were very dear to me and really seemed alive.

This I did constantly until I was about seventeen, when my thoughts turned seriously to invention. Then, to my delight, I found that I could *visualize* with the greatest facility. I needed no models, drawings, or experiments. I could picture them all in my mind.

During my second year at the Polytechnic Institute, we received a Gramme dynamo from Paris. It had a horseshoe form of field magnet and a wire-wound armature with a commutator—a type of machine that has since become antiquated. While the professor was demonstrating with this machine, the brushes sparked badly, and I suggested that it might be possible to operate a motor without such appliances. The professor declared that I could never create such a motor, because the idea was equivalent to a perpetual motion scheme.

This statement from such a high authority caused me to waver in my belief for some time. Then I took courage and began to think intently of the problem, trying to visualize the kind of machine I wanted to build, constructing all its parts in my imagination. These images were as clear and distinct as those I had conjured up to drive away the tormenting visions of my younger days. I conceived many schemes, changing them daily, but I did not at that time succeed in evolving a workable plan.

Four years later, in 1881, I was in Budapest, Hungary, studying the American telephone system, which was just being installed. But, during this interval, never for a day had I given up my attempt to visualize an electric motor without a com-

mutator. In my anxiety to visualize one that would *work*, my health again broke down, just when I was feeling that the long sought solution was near; but after six months of careful nursing I recovered.

Then, one afternoon I was walking with a friend in the City Park and reciting poetry. At that time I knew entire books by heart, word for word. One of these was Goethe's "Faust;" and the setting sun reminded me of the passage:

The glow retreats, done is the day of toil;
It yonder hastes, new fields of life exploring;
Ah, that no wing can lift me from the soil,
Upon its track to follow, follow soaring!

Even while I was speaking these glorious words, the vision of my induction motor, complete, perfect, operable, came into my mind like a flash. I drew with a stick on the sand the vision I had seen. They were the same diagrams I was to show six years later before the American Institute of Electrical Engineers. My friend understood the drawings perfectly; and to me the images were so real that suddenly I cried, "Look! Watch me reverse my motor!" And I did it, demonstrating with my stick.

THIS discovery is known as the "rotating magnetic field." It is the principle on which my induction motor operates. In this invention I produced a sort of magnetic cyclone which grips the rotable part and *whirls* it—exactly what my professor had said could never be done.

After inventing this motor, I gave myself up more intensely than ever to the enjoyment of picturing in my mind new kinds of machines. It was my great delight to imagine motors constantly running. In less than two months, I had created *mentally* nearly all the types of motors and modifications of the system which are now identified with my name.

It was in 1888, after I had come to America, that arrangements were made with the Westinghouse Company for the manufacture of this motor and for the introduction on a large scale of my system, which has since then been universally adopted. It gave the first great impetus to the harnessing of water power, to the development of trolley lines, subway systems and electric railways. It is embodied in the electric drive on battleships, and used as a means of transmitting power for innumerable purposes all over the world.

By that faculty of *visualizing*, which I learned in my boyish effort to rid myself of annoying images, I have evolved what is, I believe, a new method of materializing inventive ideas and conceptions. It is a method which may be of great usefulness to any imaginative man, whether he is an inventor, business man, or artist.

Some people, the moment they have a device to construct or any piece of work to perform, rush at it without adequate preparation, and immediately become engrossed in *details*, instead of the central idea. They may get results, but they sacrifice quality.

Here, in brief, is my own method: After experiencing a desire to invent a particular thing, I may go on for months or years with the idea in the back of my head. Whenever I feel like it, I roam around in my imagination and think about the problem without any deliberate concentration. This is a period of incubation.

Then follows a period of direct effort. I choose carefully the possible solutions of the problem. I am considering, and gradually center my mind on a narrowed field of investigation. Now, when I am deliberately thinking of the problem in its specific features, I may begin to feel that I am going to get the solution. And the wonderful thing is that if I do feel this way, *then I know I have really solved the problem and shall get what I am after.*

This *feeling* is as convincing to me as though I already had solved it. I have come to the conclusion that at this stage the actual solution is in my mind *subconsciously*, though it may be a long time before I am aware of it *consciously*.

Before I put a sketch on paper, the whole idea is worked out mentally. In my mind, I change the construction, make improvements, and even operate the device. Without ever having drawn a sketch, I can give the measurements of all parts to workmen, and when completed these parts will fit, just as certainly as though I had made accurate drawings. It is immaterial to me whether I run my machine in my mind or test it in my shop.

The inventions I have conceived in this way, have always worked. In thirty years there has not been a single exception. My first electric motor, the vaccum tube wireless light, my turbine engine, and many other devices have all been developed in exactly this way.

From Budapest I went to Paris, and there became associated with Mr. Charles Batchellor, an intimate friend and assistant of Mr. Edison. From Paris I made many trips throughout France and Germany, repairing the disorders of powerhouses; but I had no success in raising money for the development of my invention. I had already designed and constructed much improved electric machinery when Mr. Batchellor urged me to go to America and undertake the design of dynamos and motors for the Edison Company. So I decided to try my fortunes in this Land of Golden Promise.

On arriving here, I could see only the crudeness, in contrast with the gracefulness of Europe, and said, "America is twenty-five years behind Europe in civilization." But only five years later, I went abroad with new experience and became convinced that America is a century *ahead* of Europe in civilization. And that opinion I hold to this day.

ONE of the great events in my life was my first meeting with Edison. This wonderful man, who had received no scientific training, yet had accomplished so much, filled me with amazement. I felt that the time I had spent studying languages, literature and art was wasted; though later, of course, I learned this was not so.

It was only a few weeks after first meeting Mr. Edison, that I knew I had won his confidence. The fastest steamship afloat at that time, the Oregon, had disabled both her lighting engines, so that her sailing was delayed. The machines could not be removed from the ship because of the character of the superstructure, and the difficulty annoyed Mr. Edison considerably, because it seemed that the ship would be held in port some length of time.

That evening I took the necessary instruments and went aboard the ship. The dynamos were in bad condition, with

short circuits and breaks; but with the aid of the crew I put them in shape. At five that morning, on my way home, I met Mr. Edison on Fifth Avenue, with Mr. Batchellor and their assistants, just going home from their own work. When Mr. Edison saw me, he laughed and said, "Here's our young man just over from Paris running around at all hours of the night." Then I told him I was coming from the "Oregon," and that I had repaired the machines. Without a word he turned away; but as they went on I heard him say, "Batchellor, this is a d—— good man!"

Soon after I left Mr. Edison's employment a company was formed to develop my electric arc-light system. This system was adopted for street and factory lighting in 1886, but as yet I got no money—only a beautifully engraved stock certificate. Until April of the following year I had a hard financial struggle. Then a new company was formed, and provided me with a laboratory on Liberty Street, in New York City. Here I set to work to commercialize the inventions I had conceived in Europe.

AFTER returning from Pittsburgh, where I spent a year assisting the Westinghouse Company in the design and manufacture of my motors, I resumed work in New York in a little laboratory on Grand Street, where I experienced one of the greatest moments of my life—the first demonstration of the wireless light.

I had been constructing with my assistants the first high-frequency alternators (dynamos), of the kind now used for generating power for wireless telegraphy. At three o'clock in the morning I came to the conclusion that I had overcome all the difficulties and that the machine would operate, and I sent my men to get something to eat. While they were gone I finished getting the machine ready, and arranged things so that there was nothing to be done, except to throw in a switch.

When my assistants returned I took a position in the middle of the laboratory, without any connection whatever between me and the machine to be tested. In each hand I held a long glass tube from which the air had been exhausted. "If my theory is correct," I said, "when the switch is thrown in these tubes will become swords of fire." I ordered the room darkened and the switch thrown in—and instantly the glass tubes became brilliant swords of fire.

Under the influence of great exultation I waved them in circles round and round my head. My men were actually scared, so new and wonderful was the spectacle. They had not known of my wireless light theory, and for a moment they thought I was some kind of a magician or hypnotizer. But the wireless light was a reality, and with that experiment I achieved fame overnight.

Following this success, people of influence began to take an interest in me. I went into "society." And I gave entertainments in return; some at home, some in my laboratory—expensive ones, too. For the one and only time in my life, I tried to roar a little bit like a lion.

But after two years of this, I said to myself, "What have I done in the past twenty-four months?" And the answer was, "Little or nothing." I recognized that accomplishment requires isolation. I learned that the man who wants to

achieve must give up many things—society, diversion, even rest—and must find his sole recreation and happiness in work. He will live largely with his conceptions and enterprises; they will be as real to him as worldly possessions and friends.

In recent years I have devoted myself to the problem of the wireless transmission of power. Power can be, and at no distant date will be, transmitted without wires, for all commercial uses, such as the lighting of homes and the driving of aëroplanes. I have discovered the essential principles, and it only remains to develop them commercially. When this is done, you will be able to go anywhere in the world—to the mountain top overlooking your farm, to the arctic, or to the desert—and set up a little equipment that will give you heat to cook with, and light to read by. This equipment will be carried in a satchel not as big as the ordinary suit case. In years to come wireless lights will be as common on the farms as ordinary electric lights are nowadays in our cities.

The matter of transmitting power by wireless is so well in hand that I can say I am ready now to transmit 100,000 horse-power by wireless without a loss of more than five per cent in transmission. The plant required to transmit this amount will be much smaller than some of the wireless telegraph plants now existing, and will cost only $10,000,000, including water development and electrical apparatus. The effect will be the same whether the distance is one mile or ten thousand miles, and the power can be collected high in the air, underground, or on the ground.

A long time ago, I became possessed of a desire to produce an engine as simple as my induction motor; and my efforts have been rewarded. This engine has been perfected, is complete, and has been declared by the world's engineering experts to be a significant advance.

No mechanism could be simpler, and the beauty of it is that almost any amount of power can be obtained from it. In the induction motor I produced the rotation by setting up a magnetic well, while in the turbine I set up a whirl of steam or gas. The rotating part is nothing but a shaft with a few straight plates keyed to it. There are no buckets, blades nor veins. Machines of this kind can be produced that will develop ten horse-power for every pound of weight, while the lightest engines of the present day give only about one horse-power for each two pounds of weight, or one twentieth of the power developed by my turbine. I have no doubt that it is the engine of the future.

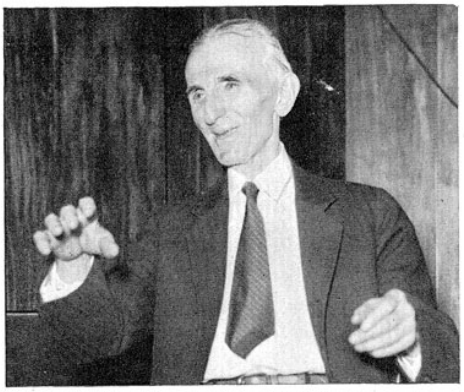
The Dearest Word

(*Continued from page 45*)

But this is not the point I am getting at: I was practically unconscious when two of the boys who could swim reached me and hauled me ashore. They had watched me struggle for some little time, as they told me when I was revived, before they realized that I was in peril, and not merely splashing about with my feet safely on the bottom; for of course the presence of the newly formed "step-off" had not been suspected by them, either.

FEBRUARY 9TH 1939 EVERY OTHER WEDNESDAY

KING OF THE COSMOS



The often scoffed at, more often acclaimed Dr. Tesla

Eccentric, 82-year-old Nikola Tesla talks more and has more to talk about than any other living inventor. Each year on his birthday he throws a party for the press at which he reads a paper on his achievements for that year. But Tesla's boasting is excusable, for the powerful electric plant at Niagara, quadruplex telegraphy, the rotating magnetic principle are numbered among his many contributions to modern science.

BY IVAN SANDROF

NIKOLA TESLA, 82, has been dubbed America's da Vinci of science. He has also been accused of out-Herooding Herod, preposterous daydreaming, crackpot thinking. If his legendary exploits have not been full hawked to the public, it is only because the Goldwyn touch is lacking. With what seems to have been the abracadabra flip of an imperial wizard, he has conjured single-handed out of his dynamic imagination, over 700 inventions, no two alike. He has quirks of genius to boot, sufficient stuff on the ball to perplex belittlers, credits to match the most prolific of inventive titans.

Not content with Manhattan, the giant has dabbled with America, Europe, Asia, the hemisphere, earth, planets, solar system. He has earned over a million and spent it just as rapidly on new will-o'-the-wisps. In recent years he has invented little of practical use, limiting himself to mental problems. Yet in full measure he continues to plague and confound authorities who cannot for the life of them understand why a man who has achieved so much should talk so much.

Each July on his birthday, Tesla throws a party for newspaper men, serves a palatable Scotch and reads a paper on his achievements for the year. Last year it was a method whereby humanity could communicate with the planets and produce dollar-a-pound radium. The year before there were three new inventions. The first, he stated, "would appear almost preposterous, the second would be considered absolutely impossible by any competent electrical engineer, the third would knock the props out from under the Einstein theory."

Tesla made his critics' eyes blink, when as a smashing climax to his 78th birthday, he divulged a death ray, perfected to the point where it could send, through the free air, concentrated beams of particles of such tremendous energy that a fleet of planes could be dropped 200 miles away, or instant death caused to armies of millions.

The *New York Times* has called Tesla one of the greatest inventors of all time. B. A. Behrend, an important electrical engineer, stated: "Were we to seize and eliminate from the industrial world the results of Mr. Tesla's work, the wheels of industry would cease to turn, our electric cars and trains would stop, our towns would be dead and idle."

The lean inventor holds honorary degrees from Yale, Columbia University, Vienna Polytechnic. In addition to the Edison Medal, he owns an Elliot-Cresson Medal given by the Franklin Institute.

Jugoslavians, in affixing a 72-nape stamp, lick the back of the inventor's likeness. King Peter honored him with the Grand Cordon of the White Eagle, highest Jugoslavian civil order. He has been publicly lauded by Sir Oliver Lodge, Lee De Forest, Lord Kelvin, John Hays Hammond, Jr., H. H. Westinghouse, Dr. Robert A. Millikan, former Secretary of Commerce Lamont and others. Delegations of European scientists have visited his birthplace to tender homage.

Tesla designed the powerful plant that first harnessed Niagara, thought out the famous Tesla coil, an electric transformer, without which the web of hot voltage wires crisscrossing the country would have been impossible. He discovered the quadruplex method of telegraphy whereby a number of messages could be flashed simultaneously over a single wire. The rotating magnetic field principle which produced the split-phase induction motor and alternating current, is Tesla's work. Other practical inventions have included generators, a better lightning rod than Franklin's, a combined helicopter and airplane, an arc light, a bladeless turbine, a new speed indicator, pressure vacuum pumps and the first major improvement in water fountains since the Italian Renaissance.

The facile inventor lives alone in a large invention-cluttered room on the 33rd floor of metropolitan Hotel New Yorker. During the winter, temperature in the room remains between 90 and 95°. Doors and windows are taped and sealed to exclude fresh air. The thin inventor goes about in a suit of ankle-clutching underwear, woolen golf hose, high-laced brogans. He dons a dressing robe when maids knock and seldom stirs from the room, although in earlier days he walked ten miles daily.

His eccentricities also extend to his food. Once an accomplished gourmet, he now munches vegetables, occasional Valencia oranges and two quarts of milk daily, which he prepares on his own double boiler. He is extremely touchy about the vegetables. Only two special chefs are allowed to tamper with the greens which must be boiled two hours or longer. Even then a struggle ensues to convince the inventor that they are not half raw.

Over six feet, sparse, with long thin arms and hands, Tesla's appearance is still striking. His ascetic face, broad and bony at the temples, bulges between the eyes, tapers sharply to nervous lips, emphatic chin. Eyes are a hypnotic light blue-gray, set deep in cavernous sockets. He expects to reach 135 and points to the longevity of his ancestors, none of whom touched the mark he has set for himself.

Two strong dreams have plagued the wizard throughout his long life—a system of wireless communication and a method of transmitting electrical energy without wires. They background his most fantastic projects, many of which smack of popular scientific thrillers. The inventions have never been fully realized, although they are fully patented and seem to have had successful minor tests.

There was a time when fulfillment of the great dreams seemed assured. It was during the late Eighties, when one American home in 30 bore electric lights, there were 8000 gas buggies snorting around, and wireless was only a faint wheeze in the ether.

Tesla and Marconi were feverishly racing against time to perfect wireless. The young Italian drew quarters in the marine station at Signal Hill, St. John's, Newfoundland; Tesla, the tip of Pikes Peak, Colorado. Their systems, similar in many respects, differed in that Marconi relied upon the ether to conduct his waves, while Tesla made use of the earth as a conductor.

Around them humanity plodded on its daily round, completely unaware of the battle between the titans—one stooped over a primitive spark transmitter within earshot of the fuming Atlantic; the other posted on a lofty mountain, matching the blazing storms with crackling bolts of homemade lightning.

In 1899, Tesla jolted the nation with a sensational announcement which seemed like extravaganza hatched jointly out of Barnum and Verne. "I have received," stated the inventor, "faint extraplanetary signals whose measured regularity was such that they could not have been accidental. I signaled back with my powerful radio transmitter and am certain that I produced a disturbance on Mars!"

The freak statement did much to arouse popular interest in the obscure wireless. An editorial in a leading newspaper reprimanded Tesla with the remark that unfortunately for the inventor's scientific standing, he had not adduced a scrap of evidence to prove it. The inventor stubbornly stuck to his statement.

An obvious inference—that Tesla's apparatus might have picked up Marconi's wandering signals—has never been pointed out.

Fired by the success of his experiments, Tesla dashed back to New York determined to give his dream a practical test on a large scale. He convinced the elder Morgan to help out, sent agents to scour the British coast for a possible site and hurried down to Long Island, where 200 acres of land had been purchased in Wardenclyffe, now Shoreham, about 65 miles from New York City.

That rural village, situated cozily

on the edge of Long Island Sound, boasted a population of 100. All of it was startled when the local builder received orders one morning to erect a number of wooden frame houses. When they were completed, a train chugged into the town disgorging a horde of workmen who occupied the cottages and set to work clearing ground. More trains arrived with several hundred workmen in all.

A number of brick factory buildings began to rise, the largest 100 feet square, several stories high. Flat and freight cars emptied supplies and fantastic-looking machinery carefully crated—huge steam boilers in sections, elephantine engines coated in grease, transformers, generators were laboriously dragged into the main structure and installed by a gang of silent, swift-working men.

Near the brick structure a monster began to rear. Of steel lattice work nearly 200 feet high, it was hooded in the shape of a gigantic toadstool capped with a circular dome of copper filigree. Workmen admitted, when no one was looking, that pipes 185 deep had been gouged into the earth, and an underground passage with conduits led from the laboratory to the tower base.

Wardenclyffe had never seen such a to-do. Each day the population came as close to the scene as was permitted and gawked surmises. Delegations from the neighboring towns of Baiting Hollow, Wading River and Miller Place abandoned their potato and cauliflower beds to see for themselves. Wild rumors circulated. Some maintained the plant would furnish power for New York, others that it would be a main signal station connecting with Europe and Australasia. More imaginative souls who believed the inventor intended communicating with Mars stepped into their backyards at night, shook their heads and marveled at the white speck in the sky which was 248 million miles from their kitchens.

The cause of all the excitement kept aloof. When not prowling about supervising the supervisors, he disappeared into a cottage and refused to come out. Interviews to newspapers, magazines and villagers were politely, but firmly refused.

Each morning at the old Waldorf-Astoria, the chef carefully packed a thermos container with a special luncheon and dispatched it by noon train to Wardenclyffe for Tesla's finicky consumption.

When the tower and buildings were completed, excess workmen returned to the city. Tesla vanished into the laboratory with a group of picked technicians. Visitors were barred by stern-lipped guards. A roar of dynamos began, and the flicker of weird fires during the night.

Suddenly, almost in a day, the sorcerer and his apprentices departed. The constant chirp of crickets replaced the droning dynamos; the night was as it had always been. Windows and doors were boarded fast. For a while a lone watchman kept vigil, then even he left.

Wardenclyffites gossiped, became used to the deserted plant, paid no attention to the fantastic colossus looming darkly against their horizon. Snow and wind shrilled through the lattice work; rust ruined the steel. Adventurous Tom Sawyers shinned the tower until the struts rotted.

A full dozen years later the buildings remained untouched—suspended in time as if unseen forces had swiftly descended and plucked the plant of its life. Drawers and desks had been yanked open, papers scattered over the floor; dead clinkers lay gray and stiff in the furnace grates; glass retorts and apparatus, fallen from supports, hung cracked and crooked. Only the constant engineering of spider webs went inaudibly on within the stricken hulk. "Tesla's Folly" had cost nearly $200,000.

The tower stood until America entered the War. When the spy hysteria seized the country and enemy radios were reported concealed and operating from tree trunks and back-yard piazzas, the citizens of Wardenclyffe begat the jitters. Rumor had it foreigners were lurking around, using the tower to contact German submarines off the Atlantic seaboard.

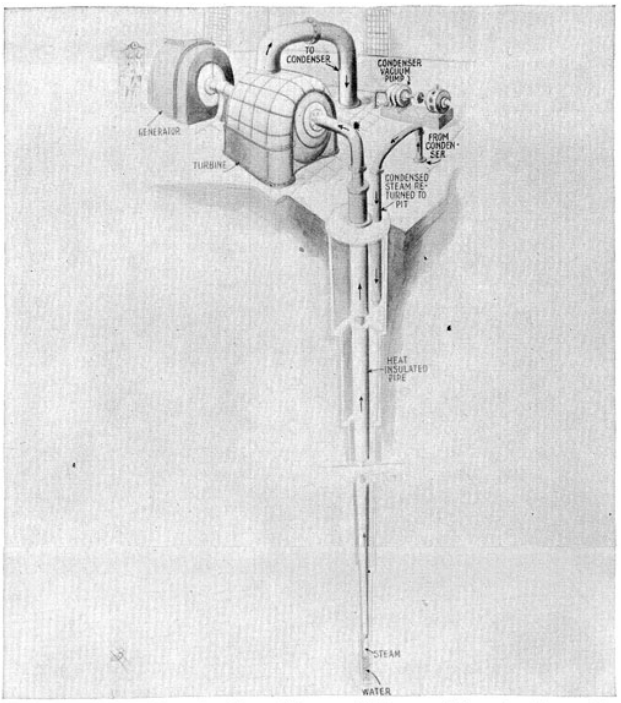
One night Government agents swooped down, found no spies, but decided to take no chances. Charges of dynamite were exploded under the foundations and the tower keeled over into junk.

To this day Jugoslavians disagree violently that Marconi invented wireless telegraphy. They claim the Italian only utilized Tesla's basic system.

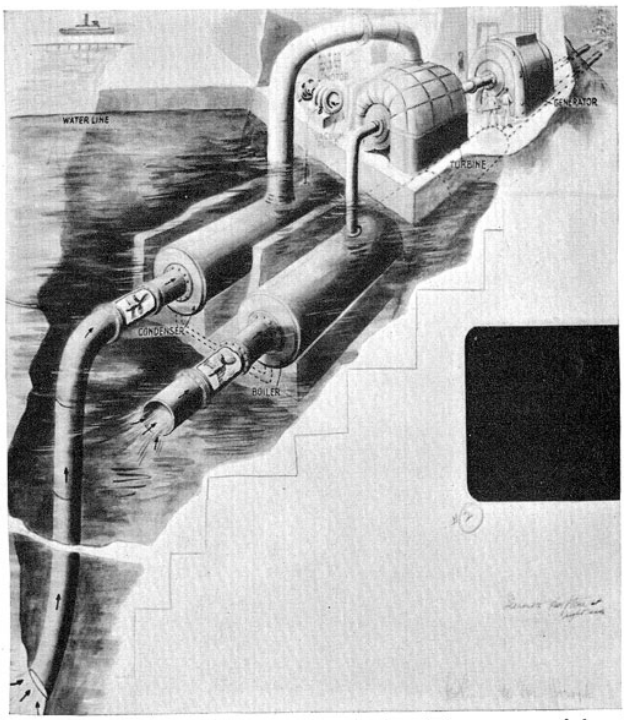
Nikola Tesla was born in Smiljan, border country of Austria-Hungary, not far from the eastern Adriatic coast. His father was a Serbian Orthodox clergyman, son of an officer who served with the grand army of Napoleon but who subsequently became a preacher. Tesla's mother, Georgina Mandic, came from an inventive family. Her son once boasted that when she was past 60 her fingers were still nimble enough to tie three knots in an eyelash.

As a stripling, the inventor was sharp-featured, frail, intense, destined by parental choice for the clergy. He rebelled early, thought of teaching mathematics and physics, finally switched to engineering. He nearly died twice before he achieved manhood, once from a severe attack of cholera, later, the result of overstudy, from a severe nervous breakdown. Family connections led to a job in Budapest, but Tesla, impatient at 23, went to Paris, where he landed work as an engineer with an electric light company. He met many Americans there, heard more about the great Edison and of the ready encouragement given to inventors with practical ideas. In 1884 he headed for the fabulous States. Five years later he became a citizen.

In New York he gravitated naturally into the workshops of Edison, then located on Goerck Street in the heart



Dr. Tesla, long given to Verne-like predictions which, also Verne-like, eventually materialize—frequently through his own ingenuity, has suggested this plan for the utilization of terrestrial heat to efficiently produce cheap power in vast abundance. As outlined in the above sketch, water is sent down a deep shaft, where it is heated by the high temperature of the inner earth and so returned in the form of steam. This steam is used to drive a turbine, after which it is passed through a condenser, and then, once again as water, returned into the shaft, so forming an unending cycle.



Another of Tesla's ideas to enable the production of cheaper power is based on the utilization of the temperature differences between that of the ocean surface water and that of the water three miles below the surface. The basic idea is not in itself original with Dr. Tesla; he has, however, devised this interesting engineering scheme which makes the idea practicable. The above sketch shows how the icy waters from the ocean depths are brought in contact with the considerably warmer waters of the upper levels, creating steam power to operate great turbines, which, in turn, drive generators.

of the teeming East Side. The association with the wizard of Menlo Park was none too happy. They worked on different tacks, Edison for direct current, Tesla for alternating. When the plant manager failed to fork over a bonus he had promised, Tesla quit, less than a year after he had entered.

Alternating current seemed doomed to extinction despite Tesla's constant efforts and enthusiasm. Few electrical engineers had worked with it; a majority were unfamiliar even with its essential features. At a most opportune time, laboratory tests by Professor Anthony of Cornell revealed that the revolutionary system had an efficiency equal to that of direct current.

Tesla became the prophet of the early 20th century. His incredible forecasts, many of which were ahead of his time, titillated popular imagination. Among them were television, smoke-annihilators, dust-absorbers, ozonizers, gyroscopes on ocean liners, electric refrigerators for home use.

He prophesied the household's daily newspaper would be printed during the night by wireless, an invention that had its first successful test in recent months. More than 35 years ago, Tesla discovered the principle of neon lamps as now used.

His appearance in print and on the lecture platform provoked unmerciful attacks. One article stated that all his "wonderful experiments" were extensions of familiar ones shown on lecture tables by the ordinary teacher of physics.

Another warned all sober-minded readers that "Mr. Tesla's recently published utterances have discredited him in the eyes of contemporary judges—philosophic and social problems upon which he freely expressed a jumble of trivial, ignorant and pretentious and erroneous opinions. His vivid writings must be read with extreme caution. His speculations on science are so reckless as to lose an interest. His philosophizing is so ignorant as to be worthless."

Adverse opinions, however, have seldom bothered the inventor. He even stated at one time that he derived a feeling of satisfaction from opposition. He has lived to confound his enemies and even to read many of their obituaries with regret.

Grown more temperamental and less communicative in recent years, something of a metaphysician and poet, Tesla prefers to brood in solitude. Strict orders are at the hotel desk not to disturb him before noon. Last winter he was severely ill, but has since recovered.

This year, for the first time, he postponed his party to the press. The reason, he stated, was a mechanical therapeutic device, almost completed, which would cure many internal disorders.

He also expects to announce this year another invention outside his field, something that will benefit the one billion-a-year poultry industry, and improve the size, quality and quantity of eggs and chickens. ●

PRISONER BEHIND THE BARS

At this prison, 87% do "go straight" when released

No really smart guy becomes a criminal. Some dumb cop will catch up with him sooner or later. Though prison life is more sensibly regulated than it was 20 years ago, it's still no picnic. Of course, once caught, a guy with sense enough to want to go straight upon completion of his stretch has ample opportunity to improve his mind; certainly one with literary aspirations has a fertile field for work.

CHARLEY and I were talking in the yard the other evening, discussing the greatest weakness in the 1,100 guys who populate our walled little city. Charley is an ex-cop, and a lot of ex-other things. His original sentence was ten to 20 years, but he went visiting over the walls one night. . . . His ten hours of freedom netted him a hectic session with the state troopers, a bullet in the leg, various contusions and abrasions, and a new sentence of 30 to 60 years. His commutation hearing comes up soon, however, with a better than average chance of getting it cut back to the original. I've still got four more to do on a ten spot, due to the Bankers' Association opposing my release on parole. They don't like for guys to borrow dough from their institutions without leaving something for security.

We finally decided that the greatest weakness among the men in here is a defense of their own faults—usually having to do with why they got sent up. I find this true in my own case and it sometimes irks hell out of me. But the bumps make a guy human or they make him no damn good. That's the trouble with too many of these birds in here. They pull a few jobs, clear 400 or 500 bucks, think they're in the money, make a big splash around some dame, and end up in here. Then it's whine. And I do hate a mug that bellyaches all the time! Sure, some of them have a kick. But what the hell! When a bird passes 18 he knows what he's getting in for. If he doesn't he should stay home with his mother.

Frankly, though, the joint is made up of about four kinds of prisoners: the guy who had decided he could beat the game and went into it with his eyes open; the guy who is forced into it by environment—improper home—lack of schooling—marriage too early in life (I oughta kick about that one! I got hitched the first time when I was 19 to a kid in the chorus of *No, No, Nanette*. She was a swell youngster, too, until an automobile ride on a fast, wet pavement ended it one night); and a surprising number of men hit these places because they just aren't equipped to earn enough dough to keep up a home. The fourth kind is the mug who may have come from either a good or a bad home but is just naturally a thief.

I don't give a damn what psychologists might say to the contrary. Men are born thieves. If they're not, most of them acquire a taste for other people's property early in life.

Out of these four groups will emerge—from the first offender—one of the following: a guy that can take it and keep his chin up; a guy that becomes vindictively hard; and the guy like myself: smart enough to know he isn't clever enough to beat the rackets and tries to learn how to make a legitimate living.

Of the first named—the guy who can take it and keep his chin up—he may or may not figure on going straight when he gets out. He mostly will, though, if he can keep clear of the prison "blowhards." Blowhards are usually petty larceny birds who run off at the mouth to these kids about all the big jobs they've pulled—a gas service station holdup, etc. The most dangerous person to the public welfare is the same first offender who listens to the blowhards. The kid is usually one easily impressed, with not too much grey matter. The result is that he actually tries to do what the big-mouthed guy claims he did. Because he isn't too smart, he shoots when it isn't necessary, and usually hits the frying pan.

The second type to emerge out of the "fish" class is the vindictively hard guy. A quiet prisoner who tends to his own business, but is really a bad man. He makes only a few friends, confides nothing, and seldom gives any trouble at all. He's thinking ahead. Once this sour guy hits the bricks again, with the intention of following the rackets, he's hard to catch. Prison has wised him up. He doesn't want to go back, so he picks some racket that's easy to beat. That is, it's hard for the law to get a conviction on him. I know of men who have been getting by for ten, 15, 20 years. They are really shrewd. Of course, plenty of these birds go straight—and some turn killer. If he turns killer, then it's just too bad for those who get in his way. But he will fry eventually.

It's only the moron who comes back to prison not once, but three, four, ten times, until he dies.

Then there's the guy like myself, who figured he could beat the rackets, found out he couldn't, and is trying to learn a legitimate one. And I'm going to make good in this writing racket or bust a rib. The others never paid much.

Right now I'm in my 30th year, six foot two, a nose that's been busted six times and been rebuilt in Walter Reed Hospital, a jagged scar—well, never mind how I got it. I finished high school in three years, got in a jam and joined the navy, stayed there for three years, attended prep school for the academy. Drove one of the officers about for six months and saw